SPECIFICATIONS

FOR

TRIPLE-EXPANSION

TWIN-SCREW PROPELLING ENGINES,

WITH BOILERS AND AUXILIARY MACHINERY,

FOR

"New York."

AN ARMORED CRUISER OF ABOUT 8,100 TONS CRUISING DISPLACEMENT,

TO MAKE A SPEED OF TWENTY KNOTS PER HOUR.

BUREAU OF STEAM ENGINEERING,
NAVY DEPARTMENT,
WASHINGTON, D. C.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1890.

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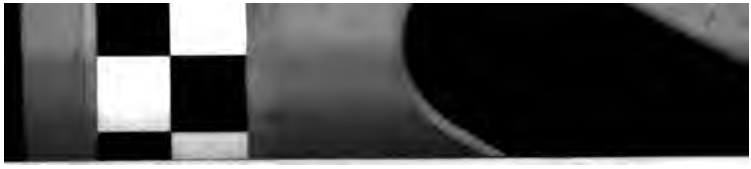

LIST OF PLANS ACCOMPANYING THESE SPECIFICATIONS.

General arrangement of the machinery and boilers in the vessel.
General arrangement of engines.
High-pressure cylinders.
Intermediate-pressure cylinders.
Low-pressure cylinders. (2 sheets.)
Engine-frames.
Engine bed-plates. (2 sheets.)
Condensers.
Air-pumps and engines.
Boilers. (2 sheets.)

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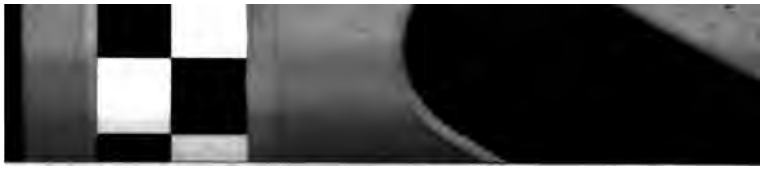
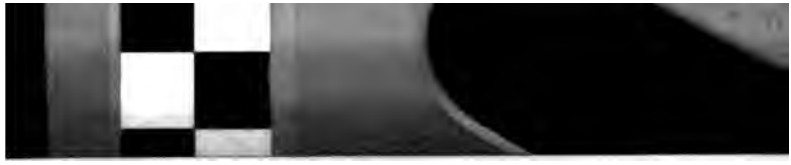
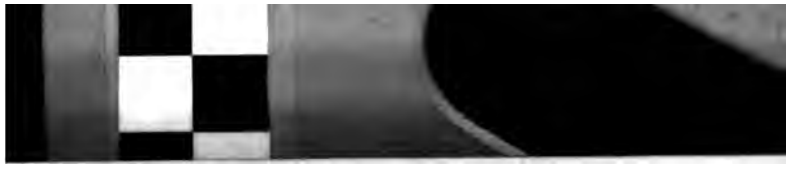






SPECIFICATIONS

FOR

TRIPLE-EXPANSION

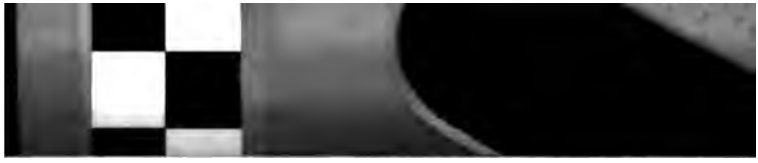
TWIN-SCREW PROPELLING ENGINES,

WITH BOILERS AND AUXILIARY MACHINERY.

REFERENCE BEING HAD TO THE DRAWINGS ACCOMPANYING AND FORMING PART OF THESE SPECIFICATIONS.

1. GENERAL DESCRIPTION.

There will be four sets of propelling engines, two of which will be rights and two lefts, placed in two water-tight compartments and separated by a middle-line bulk-head. There will be two sets of engines on each shaft. The crank-shafts of the two sets of engines for each propeller must be so arranged that, by means of an easily operated coupling, the forward set may be quickly and easily connected with or disconnected from the after one at will. For ordinary cruising the after set attached to each shaft will be used. These engines will be of the vertical inverted-cylinder, direct-acting, triple-expansion type, each with a high-pressure cylinder 32 inches, an intermediate-pressure cylinder 46 inches, and a low-pressure cylinder 70 inches in diameter—the stroke of all pistons being 42 inches. It is estimated that the collective indicated horse-power of propelling, air-pump, and circulating-pump engines should be 16,000 when the main engines are making about 129 revolutions per minute. The high pressure cylinder of each engine will be forward and the low-pressure cylinder aft. The main valves will be of the piston



type, worked by Stephenson link-motions with double-bar links. There will be one piston-valve for each high-pressure cylinder, two for each intermediate-pressure cylinder, and two for each low-pressure cylinder. Each main piston will have one piston-rod, with a cross-head working between guides. The framing of the engines will consist of cast-steel inverted Y-frames, two for each cylinder. The engine bed-plates will be of cast-steel, supported on wrought-steel keelson plates built in the vessel. The crank-shafts will be made in three sections. All shafting will be hollow. The shafts, piston-rods, connecting-rods, and working parts generally will be forged of mild open-hearth steel.

The condensers will be made of composition and sheet-brass. There will be one condenser for each propelling engine. Each main condenser will have a cooling surface of about 5,559 square feet, measured on the outside of the tubes, the water passing through the tubes. For each propelling engine there will be two single-acting vertical air-pumps worked by a two-cylinder vertical inverted simple engine. The main circulating-pumps will be of the centrifugal type, one for each condenser, worked independently. The propellers will be right and left, of manganese-bronze, or approved equivalent metal.

Each engine-room will have an auxiliary condenser, made of composition and sheet-brass, of sufficient capacity for one-half the auxiliary machinery, each condenser being connected with all the auxiliary machinery. Each of these condensers will have a combined air and circulating-pump.

There will be six double-ended main and two single-ended auxiliary boilers, of the horizontal-return fire-tube type, all to be made of steel. The main boilers will be about 15 feet 3 inches outside diameter and about 21 feet 3 inches long. The auxiliary boiler will be about 10 feet mean diameter and 8 feet 6 inches long, all constructed for a working pressure of 160 pounds per square inch. The main boilers will be placed in two watertight compartments, each compartment containing three double-ended boilers. There will be two athwartship

fire-rooms in each of the main boiler-compartments. Each of the double-ended boilers will have eight corrugated furnace-flues, 3 feet 3 inches internal diameter. The total heating surface for the main boilers will be about 31,190 square feet, measured on the outer surface of the tubes, and the grate surface 988 square feet. The auxiliary boilers will be placed above the protective-deck; each will have two corrugated furnace-flues, 2 feet 9 inches internal diameter. The total heating surface for the two auxiliary boilers will be about 1,937 square feet, measured on the outside of the tubes, and the grate surface about 64 square feet. There will be in each main fire-room in which the check-valves are placed two approved main and two approved auxiliary feed-pumps, and in each auxiliary fire-room an approved main and an approved auxiliary feed-pump; also in in each engine-room an auxiliary feed-pump, a fire and bilge-pump, and a water-service pump. There will be two smoke-pipes.

The forced-draft system will consist of three blowers for each fire-room, for the main boilers, and one in each fire-room for the auxiliary boilers, the blowers for the main boilers discharging into an air-tight fire-room. Air-tight bulkheads will be fitted so as to reduce the space to be maintained under pressure.

There will be steam reversing-gear, ash-hoists, turning-engines, auxiliary pumps, engine-room ventilating-fans, engine for work-shop machinery, hydraulic pumping plant for various purposes, gun-table or turret-turning engines, a distilling apparatus, and such other auxiliary or supplementary machinery, tools, instruments, or apparatus as are described in the following detailed specifications or shown in the accompanying drawings.

2. CYLINDERS.

They will consist of casings of best quality of cast-iron, with working-linings for the cylinders and valve-chests. The cylinder casings will include the valve-chests, steam-ports and passages, the lower heads, and the various brackets to which the cylinder-supports will be attached.

The steam and exhaust-ports will be smoothly cored to the dimensions shown in drawings, the walls of the passages being strongly stayed by ribs or bolts.

The brackets for securing the cylinder tie-rods will be so faced that when bolted together the centers of the high and intermediate-pressure cylinders will be 8 feet 8¼ inches apart, and the centers of the intermediate and low-pressure cylinders 8 feet 3 inches apart, with the cylinder-axes all in one plane and parallel. The cylinder casings will be bolted at the bottom to their frames by body-bound steel bolts, and secured to each other at the top by forged-steel stay-rods, fitting in sockets on the cylinder casings.

They will be in a vertical position when bored to their respective diameters.

3. HIGH-PRESSURE CYLINDER CASINGS.

The heads will be cast with double walls and the barrels will be 1⅜ inches thick. Each will have one piston-valve. They will be faced and bored, as shown, for the reception of the working-cylinder linings and for the valve-chest linings. The brackets at the bottom for attachment of the supporting frames will be well ribbed and faced. There will be brackets bolted to the casing, faced and fitted with caps for securing the tie-rods from the intermediate cylinder casing. The walls of the steam passages will be properly stayed. There will be a 6½-inch hand-hole in the lower head. There will be facings, flanged and ribbed where necessary, for the attachment of the cylinder and valve-chest covers, steam-pipes, exhaust-pipes, piston-rod stuffing-boxes, relief-valves, hand-hole plate, drain-cocks, indicator-pipes, drain-pipes, oil-cups, starting-valve pipes, and starting-valve chests. The unfinished part of the bore will be pickled to remove the scale.

4. INTERMEDIATE-PRESSURE CYLINDER CASINGS.

The heads will be cast with double walls and the barrels will be 1½ inches thick. Each will have two piston-valves. There will be brackets bolted to the casing, faced

and fitted with caps for securing the tie-rods from the high and low-pressure cylinder casings. There will be faced brackets for the supporting frames. There will be a 10 x 14-inch man-hole in the lower head. There will also be facings for attaching the steam and exhaust pipes, receiver safety-valves, receiver live-steam pipes, relief-valves, starting-valve pipes, starting-valve chests, jacket steam and drain-pipes, piston-rod stuffing-boxes, and man-hole covers; also for indicator-pipes, oil-cups, and drain-cocks. The unfinished part of the bore will be pickled to remove the scale.

5. LOW-PRESSURE CYLINDER CASINGS.

The heads will be cast with double walls and the barrels will be 1½ inches thick. There will be brackets bolted to the casing, faced and fitted with caps for securing the tie-rods from the intermediate-pressure cylinder casings. Each will have two piston-valves. There will be faced brackets for the supporting frames, also facings for man-hole covers, steam and exhaust-pipes, auxiliary exhaust-pipes, receiver safety-valves, receiver live-steam pipes, starting-valve pipes, starting-valve chests, jacket steam and drain-pipes, relief-valves, piston-rod stuffing-boxes, indicator-pipes, oil-cups, and drain-cocks. There will be a man-hole 15 inches in diameter in the lower head. The unfinished part of the bore will be pickled to remove the scale.

6. CYLINDER LININGS.

They will be of close-grained cast-iron as hard as can be properly worked, turned and faced to fit the cylinder casings. Each lining will have a bearing at about the middle of its length and at each end.

The linings at the top will be secured to the casings by round-headed countersunk steel bolts, placed radially around the counterbore, and spaced as shown on the drawings. The bolt-holes in the linings will be counterbored to receive the heads of the bolts, the nuts being on the outside of the casings.

The linings, after being secured in place in the casings, will be smoothly and accurately bored to diameters

of 32, 46, and 70 inches for the high, intermediate, and low-pressure cylinders, respectively, and to a thickness of 1¼ inches, the boring to be done with the cylinders in a vertical position. The linings will be counterbored at both ends, leaving the working bores 3 feet 8⅛ inches long. The unfinished parts of the linings will be pickled to remove scale.

The joint at the lower end of each liner of the intermediate-pressure and low-pressure cylinders will be made tight, with allowance for expansion, by a copper ring about $\frac{1}{16}$ inch thick. This copper ring will be backed by a wrought-iron ring 1½ inches wide and $\frac{7}{16}$ inch thick, the two rings together being secured to the cylinder-liner by ⅝-inch wrought-iron screws, spaced not over 3 inches.

A similar backing-ring and screws will make a tight joint between the same copper ring and the facing provided on the cylinder casing. The facings of lining and casing and the edges of the backing-rings will be chamfered to allow of free expansion.

7. CYLINDER COVERS.

They will be of cast-iron, well stiffened by ribs, each fitted with a 15-inch man-hole. They will be so formed as to leave as little clearance as practicable.

Annular recesses will be cored for the heads of the piston-follower bolts. Each cover will be turned and faced to fit its cylinder casing, bored and faced at man-hole, and finished on outside of flanges.

The cover of the high-pressure cylinder will be secured to the cylinder casing by thirty, the cover of the intermediate-pressure by thirty-six, and the cover of the low-pressure by fifty-four 1¼-inch steel studs.

Holes will be drilled and tapped for jack-bolts and eye-bolts.

The thickness of the covers will be 1¼ inches for the high and intermediate-pressure cylinders and 1⅜ inches for the low-pressure cylinders.

8. CYLINDER MAN-HOLE COVERS.

They will be of cast-iron, shaped as shown in the drawings, faced to fit man-holes, and finished on the outside

of flanges. They will be secured by 1⅛-inch steel studs, spaced as shown in the drawings, and will have holes drilled and tapped for jack-bolts.

9. CYLINDER CLEARANCES.

Care will be taken that the clearances in the cylinders are made no larger than absolutely necessary. After the engines are set up in place and connected, the volume of the clearance at each end of each cylinder will be carefully measured by filling the space with water or oil, and the result plainly marked on some conspicuous part of the cylinder casing. Marks will also be made on the cross-head guides showing the position of the pistons when the clearances were measured.

10. STEAM-JACKETS.

The intermediate-pressure and low-pressure cylinders will be steam-jacketed on sides and bottoms.

The space left around the working linings for steam-jackets will be ¾ inch in depth. All ribs must be cored out so as to allow a free circulation of the jacket-steam and a free drainage of the water of condensation.

Steam for the jackets will be taken from the main steam-pipe in each engine-room, on the boiler side of each engine stop-valve, by a 2-inch pipe. From this pipe a 1½-inch branch will lead to the intermediate-pressure jacket. This branch will have a 1½-inch adjustable-spring reducing-valve, adapted to pressures of from 20 to 80 pounds above atmosphere.

Another 1½-inch branch will lead to the low-pressure jacket. This branch will have a 1½-inch adjustable-spring reducing-valve, adapted to pressures of from 0 to 30 pounds above atmosphere.

Each branch steam-pipe will have a stop-valve close to the jacket.

There will be on each jacket steam-pipe, on the jacket side of the reducing-valve, a 1½-inch adjustable-spring safety-valve, adapted to the same pressures as the reducing-valves.

A 1-inch drain will lead from the lowest part of each jacket to an approved automatic trap with blow-through and by-pass pipes and valves, thence to the lower part of the feed-tank, with a branch to the bilge. Each drain-pipe will have a stop-valve close to its jacket. The drainage system of the jacket of each cylinder will be entirely independent as far as the trap-discharge, from which point the drains may be in common. All pipes in the jacket-drain system will have union joints so as to be easily overhauled.

11. VALVE-CHESTS.

The valve-chest of each high-pressure cylinder will be fitted for one piston-valve, each intermediate-pressure and each low-pressure for two.

There will be openings at each end for inserting and removing the valves and working linings, and there will be a man-hole fitted with a cover on the low-pressure valve chests 12 x 16 inches. The chests will be accurately bored and faced for the reception of the working linings.

Before the insertion of the linings the steam and exhaust passages must be thoroughly cleaned out and pickled, and care taken that the passages are nowhere contracted to less than the specified areas.

Each intermediate-pressure and each low-pressure valve-chest will have a 3-inch adjustable-spring safety-valve of approved pattern. They will be loaded to 80 and 25 pounds, respectively, for the intermediate and low-pressure chests.

All valve-chests will also be fitted with approved composition drain-cocks or valves that may be operated from the working-platform, the valves to discharge through pipes into the bilge and feed-tanks, with the necessary valves for directing the water to either.

12. VALVE-CHEST LININGS.

There will be a working lining at each end of each valve-chest for each piston-valve. They will be of close-grained cast-iron as hard as can be properly worked,

accurately turned and faced to fit the casings, and accurately bored to an internal diameter of 16 inches in the high and in the intermediate-pressure, and 30 inches at the top and 28½ inches at the bottom in the low-pressure, leaving the walls 1 inch thick for the high and intermediate-pressure and $1\frac{1}{16}$ inches for the low-pressure valve-chests.

They will be forced into place, making all joints perfectly tight, and secured by screws tapped half into the linings and half into the casings.

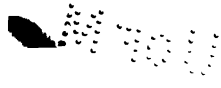
The steam-ports will have alternating right and left diagonal bridges, of such a section as to permit the easy passage of steam, taking up not more than one-fourth of the port area.

The edges of all ports will be finished to a uniform outline.

13. VALVE-CHEST COVERS.

They will be made of cast-iron, as drawn, and will be well ribbed, as shown. They will be finished all over on the outside, except the recesses between the ribs.

All flanges will be turned and faced to fit the openings in valve-chests and finished on the outside and edges. Each lower cover will be faced and bored to receive the valve-stem stuffing-boxes. The cylinder for the balance pistons for the high and intermediate-pressure valves will form part of the upper covers for the valve chests and will be bored to diameters of 4 and 4¾ inches respectively. The upper end of the low-pressure valve-stems will be guided as shown on drawing. Lugs will be fitted in the steam-chests to prevent the rings from overriding the seats when valves are disconnected. There will be approved provision for proper oiling of the valve-stems. Each upper cover of the high-pressure and intermediate-pressure valve-chests will have a smaller cast-iron cover finished all over, flanged and bolted on, over the openings for the balance-pistons. The lower covers will have the necessary faces for securing valve-stem cross-head guides.



14. PISTON-VALVES.

The high-pressure valves will be of cast-iron and the intermediate-pressure and low-pressure piston-valves will be of composition, the thicknesses to be as shown on the drawings. Each valve will be made in two parts. Each of these parts will consist of a hollow piston, with follower, wearing-ring, and two packing-rings. The two parts will be separated when in position by a distance-piece for the high and intermediate-pressure and a tube for the low-pressure of such lengths as to make the steam and exhaust-laps as required. The diameter of the upper part of the low-pressure valve will be 1½ inches larger than the bottom part, the live steam being between the end sections. The two sections of the low-pressure valve will be connected by a steel tube 19½ inches internal diameter and $\frac{3}{16}$ inch thick. The tube will be flanged at the ends and bolted to the end sections as shown on the drawings.

The followers of the high-pressure valves will be of cast-iron or cast-steel, and those of the intermediate-pressure and low-pressure valves of composition, secured in place by steel through-bolts with wrought-iron nuts and brass split-pins. The follower-bolts will pass through lugs on the inside of the valve-shell and have their heads so formed and fitted as to prevent turning. The wearing-rings will be of cast-iron, finished to a neat end fit between packing-rings, and they will be smoothly and accurately turned and faced. The packing-rings will be of hard cast-iron, turned larger than the bore of valve-seat, cut obliquely, tongued, and sprung into place.

15. VALVE-STEMS.

The high-pressure valve-stems will take hold of the link-blocks.

The lower end of each intermediate-pressure and low-pressure valve-stem will be secured to its cross-head by a collar-nut above and below the cross-head, the nuts being kept from turning by set-screws.

The holes in cross-heads of valve-stems will be elliptical.

charge into a pipe leading to the fresh-water side of the condenser, with a branch to the bilge. This pipe will have a stop-valve near the condenser, and will have a spring non-return valve, without hand-gear, which can open to the bilge-discharge when the drain to condenser is closed, but which will prevent air entering the condenser at any time. Small drain-cocks will be fitted to the lowest parts of drain-pipes.

18. ENGINE THROTTLE-VALVES.

Each engine will have an 11½-inch throttle-valve, bolted to the high-pressure cylinder casing. Each throttle will consist of two gridiron slide-valves, one above the other. The slide nearest the seat will be worked by a steam-piston working in a cylinder, whose valve will be controlled by a floating-lever so fitted that the throttle-valve will follow the movement of a hand-lever at the working-platform. This throttle will have a locking-gear worked from the platform, which will hold the valve wide open when desired. Steam for the controlling cylinder will be taken from the auxiliary steam-pipe, with a stop-valve easily reached from the working-platform.

The upper throttle-slide will be worked by a screw-stem, the gear operating the stem being worked by an 18-inch hand-wheel at the platform, where it will have an index divided as directed.

The steam-actuated throttle is intended for use in quick working, and the hand-moved valve for fine adjustment.

The spindles of both valves will be horizontal. The valves, stems, and casings will be of composition. The casing will be made in two parts, divided near the plane of the valve-face.

19. STARTING-VALVES.

There will be a starting-valve for each cylinder of the propelling-engines, on the outboard side above the working-platform. These will be piston-valves—each complete in itself—with both steam and exhaust-ports. The

valves, chests, and covers will be of con
The valves must be securely fastened to the
The valve-chests will be bolted to the facings
for them. Steam for the starting-valves will
from the main steam-pipes outside the throt
by a pipe having a branch to each valve. T
be a stop-valve in this pipe, to be worked
working-platform; also a stop-valve close to ea
chest. Each starting-valve will connect with
of its cylinder by a 2-inch copper pipe. The
will all exhaust into a 2½-inch pipe leading to
denser, the branch from each valve having a s
close to the valve-chest. Each steam-port of e
ing-valve will have an area of about 3 squar
Each starting-valve will be worked by a lev
working-platform; these levers to be placed in
order as their respective valves, and arranged
in the same direction as the desired motion of t
The valves are to be in middle position when th
are horizontal.

20. PISTON-ROD STUFFING-BOXES.

They will be made of composition and fitted
proved metallic packing, with efficient means o
tion. The packing of each stuffing-box will be
at least two independent sections, so that ir
injury to one section the other will make a ti
alone; this packing to be in all respects equal t
in the market and subject to the approval of th
of Steam Engineering.

21. VALVE-STEM STUFFING-BOXES.

They will be made of composition and fitted
proved metallic packing, with efficient means o
tion. The packing of each stuffing-box will be
at least two independent sections, so that ir
injury to one section the other alone will mak
joint; this packing to be in all respects equal t
in the market and subject to the approval of th
of Steam Engineering.

22. PISTONS.

They will be made of cast-steel, and will be dished.

The followers, made as shown in the drawings, will be of cast or forged-steel, 1½ inches thick reduced to 1¼ inches thick at the circumference, secured in place by 1¼-inch bolts spaced as shown on drawings.

The follower-bolts will be steel studs, screwed into the pistons; the bodies of the studs to be square, passing through square holes in the followers. The follower-bolt nuts will be of wrought-iron, finished and case-hardened, each nut to be secured in place by a brass split-pin of ample size.

Each piston will have two packing-rings, each 1¼ inches wide and ¾ inch thick, of hard cast-iron, cut obliquely, and tongued.

The packing-rings will be set out by steel springs of approved pattern, all set to an equal and proper tension. There will be sufficient clearance between the piston and cylinder to allow for difference of expansion.

Each packing-spring must be so secured in the piston as to be firmly held in place and easily inserted and removed. The springs must be of best spring-steel, properly tempered.

Each piston must be carefully gauged, and care taken that the clearance between the piston and cylinder-head and cover is as called for on the drawings.

When completed the pistons must be carefully weighed, and no excess of weight will be allowed over that due to the dimensions shown in the drawings.

23. PISTON-RODS.

The piston-rods will be of forged-steel, 6¼ inches diameter. They will be turned to fit the pistons and cross-heads, with collars, as shown, and fitted each with a composition nut at piston end secured by a screw stop-pin and a steel nut with collar at cross-head end. The nut at cross-head end will be secured by a set-screw. The parallel parts will be smoothly and accurately turned.

Each piston-rod will have, at its seating in the piston, a collar 7½ inches diameter and 1¼ inches thick, well filleted, and recessed in the piston as shown.

At the cross-head end each piston-rod will have a collar 7 inches diameter and 1 inch thick.

From the collar to the end of the cross-head the rod will taper to 5¼ inches diameter.

The piston-rod will be kept from turning in the piston and cross-head by stop-pins.

24. CROSS-HEADS.

The cross-heads will be made of cast-steel; the pins will be 7 inches diameter and 8 inches long, and will have a central hole tapering from 3½ to 2 inches diameter. Each cross-head will have wearing slippers working between guides on the inverted **V**-frames. The hole for the piston-rod will be accurately bored to fit the taper on the piston-rod. The slippers will be of composition faced with white-metal fitted in dovetailed recesses, and hammered in place.

25. CONNECTING-RODS.

The connecting-rods, with their caps and bolts, will be of forged-steel, finished all over.

They will be 84 inches long between centers, turned 6¼ inches in diameter at small end and 9 inches at large end, the sides being faced off to a uniform thickness of 6¼ inches.

The cross-head end of each rod will be forked to span the cross-head.

The crank-pin end of each connecting-rod will be increased in thickness to 11 inches for the after engine and 14 inches for the forward engine, faced on each side, and bored for the brasses.

Both ends will be provided with brasses and steel caps and bolts with recessed nuts, and set-screws.

The cap-bolts will pass partly through the brasses and at the crank-pin end will be fitted with set-screws for holding their weight when backing off the nuts.

In each jaw and each cap of each connecting-rod bolts will be fitted, passing through the metal of the rods or caps, and tapped into the corresponding lip of the crank-pin brasses or distance-piece to prevent closing-in when heated, each of these bolts being secured by a set-screw.

Composition distance-pieces will be fitted between the connecting-rods and caps; they will be so fitted as to be removable without taking out the cap-bolts, and will be channeled so as to be easily reduced when taking up lost motion.

The caps will each be fitted with two eye-bolts for handling.

26. CRANK-PIN BRASSES.

They will be accurately fitted to the connecting-rods, and secured as before specified. They will be fitted with approved white-metal in strips, accurately fitted to the crank-pins, and properly fitted for distribution of oil. They will be faced with sufficient clearance between crank-webs to prevent nipping when heated.

27. CROSS-HEAD BRASSES.

They will be accurately fitted to the cross-head pins, and properly fitted for the distribution of oil.

28. ENGINE-FRAMES.

Each cylinder will be supported by two cast-steel inverted **V**-frames as shown in the drawings. The upper ends of the frames will be faced and secured to brackets on the cylinders by body-bound bolts where shown. The lower ends of the frames will be faced and secured to bed-plates by body-bound bolts.

The upper portion of the inboard inverted **V**-frames on the inside will be faced to receive a cast-iron wearing-guide for the cross-head, and the upper portion of the outboard inverted **V**-frames on the inside will be faced to form a backing-guide. Facings will also be provided for reversing-gear, as may be required.

29. BED-PLATES.

They will consist each of steel castings of **I**-section; the upper and lower flanges will be connected to the web and stiffened by ribs, as shown. They will be properly

finished and faced for crank-shaft brasses and caps, and for the flanges of the supporting-frames and columns. The bed-plates will be secured to the engine keelsons by 1¼-inch body-bound forged-steel bolts, setting up on raised facings on the lower flange.

30. CRANK-SHAFT BRASSES AND CAPS.

The brasses for each bearing will be cylindrical, in two parts, lined with approved white-metal, fitted in dovetailed recesses and hammered in place, and will be fitted with ample oil-channels, faced at ends, and turned to fit cap and chock, as shown, and accurately bored to fit the journals of shaft. The caps will be of steel, with lips to match the jaws. Each cap and upper brass will have an oval hand-hole for the purpose of feeling the journal. This hand-hole will have a cover, with handle—the lower part of the cover being formed into a perforated tallow-box, reaching to within a quarter of an inch of the journal.

The caps will be secured by two stud-bolts of forged-steel, 3¼ inches in diameter; the part beyond the nuts will be fitted with a split-pin.

The caps and brasses will be tapped and fitted with eye-bolts for handling.

After the engines are secured in the vessel the brasses will be bored out in place to perfect alignment, if required. They will also be tried on their shafts and any defects made good by scraping to a proper bearing.

The brasses will be so fitted that the only bearing of the journals will be on the surface of the white-metal.

Provision will be made for circulating water either around or through the bottom-brasses.

31. CROSS-HEAD GUIDES.

The guide to take the thrust when going ahead will be of cast-iron. It will be bolted to the inverted **V**-frame. The back of the guide will have recesses covered with wrought-iron plates so as to form a water-passage for circulation of water to keep the guide cool. Cast-iron lips will be cast on each side of each go-ahead guide to take the side thrust.

The guides will be smoothly and accurately finished, and will be fitted in place to proper alignment. Brass oil-boxes will be screwed to lower end of each guide.

32. VALVE-GEAR.

It will be of the Stephenson type, with double bar-links. All valves will be worked direct. There will be one cross-head for the intermediate-pressure and one for the low-pressure valve-stems.

The valve-gear will be so adjusted that the mean cut-off in full gear for both ends of each cylinder will be at 0.7 stroke.

33. ECCENTRICS.

They will be of cast-iron, each in two parts.

The two parts of each eccentric will be neatly fitted together and secured by two forged-steel bolts. They will be bored out to a snug fit on the seatings and turned accurately on the outside to an eccentricity of 4¾ inches for the high, the intermediate, and the low-pressure. The seatings for the eccentrics will be on the crank-shafts. The eccentrics will be recessed at each side for the flanges of the eccentric-straps. Each backing eccentric will be securely keyed on the shaft, and each go-ahead eccentric will be secured to the corresponding backing eccentric by through-bolts in slotted holes, the holes to be filled up after the eccentrics are set.

The high-pressure and intermediate-pressure eccentrics will be interchangeable.

34. ECCENTRIC-STRAPS.

They will be of composition, finished all over, made with flanges to fit the recesses of eccentrics and with lugs for the clamping-bolts and for the eccentric-rods. The two parts of each strap will be held together by two forged-steel bolts with finished heads, lock-nuts, and split-pins, and fitted with channeled brass distance-pieces. Each strap will be accurately and smoothly bored to fit the eccentrics both on face and recesses, and properly channeled for oil.

35. ECCENTRIC-RODS.

They will be of forged-steel, finished all over. Each rod will have a T-head secured to its eccentric-strap by two forged-steel stud-bolts with nuts locked in place.

The upper end of each rod will be forked to span the link, and fitted with brasses with adjustable wedge-blocks.

The two brasses in the forks of each rod must be fitted accurately in line with each other, and smoothly bored to fit the link-pins. The distance from centers of eccentrics to centers of link-pins will be 7 feet 4 inches.

The high and intermediate-pressure eccentric-rods will be open and those of the low-pressure will be crossed.

36. MAIN LINKS.

They will be of the double-bar pattern, of forged-steel, finished all over. They will all have the pins for eccentric-rods forged on and finished to 25 inches between centers. Extensions of the pins at one end of each link will form the pins for suspension-rods. Each pair of bars will be secured together by through-bolts of forged-steel, and thimbles fitted with forged-steel nuts well secured with split-pins.

37. LINK-BLOCKS.

They will be of forged-steel, finished all over. They will consist each of a link-block pin terminating at each end in a pair of jaws to span the corresponding bar of the link. The jaws will be fitted with composition gibs finished to the curve of the links, the outer gibs being fitted with keys with screw adjustment.

38. SUSPENSION-LINKS.

Each Stephenson link will be suspended from the corresponding arm of the reversing-shaft by forged-steel suspension-links.

The ends of these links will be fitted with composition bushings, bored to fit suspension-pins on main links and pins on reversing-shaft arms.

39. VALVE-STEM CROSS-HEADS AND GUIDES.

The intermediate-pressure and low-pressure valve-stems will have cast-steel cross-heads, the cross-heads

taking hold of the link-blocks directly. The ends of these valve-stems passing through the bosses in cross-heads will be threaded, and will be secured to cross-head by a collar-nut above and below boss, the holes in the bosses being elliptical. The collar-nuts will be kept from turning by set-screws. A key-way will be cut in both the valve-stem and its boss in the cross-head to receive a key to keep the valve-stem from turning. The cross-head guides will be cast-steel brackets bolted to the valve-chest covers. The high-pressure valve-stem will take hold of the link-block directly. The high-pressure stem will be guided by a bracket bolted to the valve-chest cover.

40. REVERSING-GEAR.

The reversing-gear for each engine will consist of a steam cylinder and a hydraulic controlling cylinder placed vertically and acting directly on an arm fixed on the reversing-shaft. Each will be placed on the inboard side of its engine, opposite the intermediate-pressure cylinder column. The steam piston-rod will be secured to a steel cross-head connecting with the arm on the reversing-shaft. The piston-rod will pass through the controlling cylinder with uniform diameter. The valve of the steam cylinder will be of the piston pattern, of composition, working in a composition-lined valve-chest. There will be a by-pass valve on the hydraulic cylinder, which will be worked by a continuation of the stem of the steam piston-valve. These valves will be worked by a system of differential levers, the primary motion being derived from the hand-lever on the working-platform and the secondary motion from a pin on the reversing-arm, all parts being so adjusted that the reversing-engine shall follow the motion of the hand-lever and be firmly held when stopped. There will be a stop-cock in the by-pass pipe of the hydraulic cylinder, and a pump for reversing by hand will be connected to the hydraulic cylinder with its lever convenient to the working-platform. The by-pass pipes will be connected to the valve-box of the hand-pump in such a way as to leave the hand ar-

rangement always in gear. The piston of the hydraulic cylinder will be packed by two cup-leathers. Steam for the reversing-engine will be taken from the auxiliary steam-pipe.

41. REVERSING-SHAFTS.

There will be one forged-steel reversing-shaft for each engine. It will have five arms, two for the reversing-engine and one for each link. The shaft will be supported by suitable bearings. Each reversing-arm for the links will be made with a slot, fitted with a cast-steel block, to which the suspension-rods will be attached. Each block will be adjustable in the slot of its arm by a screw and hand-wheel with approved locking device, and will be fitted with a suitable index. The slots in these arms will be so arranged that the links may always be thrown into full backward gear irrespective of the position of the block in the slot; and the length of the slots will be such that the cut-off may be varied from 0.5 to 0.7 of the stroke. All the arms will be neatly fitted and keyed to the shafts.

42. EXHAUST-PIPES.

One 14½-inch copper pipe with two 16½-inch branches will lead from the exhaust side of each high-pressure valve-chest to the valve-chest of the corresponding intermediate cylinder.

A 20-inch copper pipe will lead from the exhaust side of the intermediate-pressure valve-chest, and expanding to 22 inches diameter where it bolts to low-pressure valve-chest.

A 24½-inch copper pipe will connect the low-pressure valve-chest with the condenser.

43. REVERSING-SHAFT BEARINGS.

They will be made of cast-steel, with bottom brasses and composition caps, and will be securely bolted to their supports. They will be bored to fit the journals of the shafts.

The caps will be secured with lock-nuts.

44. WORKING-PLATFORMS.

The floors on the outboard side of each main engine, between the high and intermediate-pressure cylinders, will be conveniently arranged to serve as working-platforms. The counter, revolution-indicators, clock, gauges, telegraph-dials, and other engine-room fittings will be so placed near the working-platforms as to be in full view while working the engines. Speaking-tube mouth-pieces and telegraph-levers will be conveniently placed.

45. WORKING-LEVERS AND GEAR.

There will be at each working-platform the following hand-gear, viz:

One reversing-lever;
Three starting-valve levers;
Three cylinder drain-cock levers;
Hand-reversing pump-lever;
Throttle-valve hand-wheel;
Bleeder-valve hand-wheel;
Reversing-engine stop-valve hand-wheels for steam and exhaust;
Starting stop-valve hand-wheel.

All levers will have spring-latches of "locomotive pattern." The latches on reversing-levers will be of the best type and subject to the approval of the Bureau of Steam Engineering.

46. SHAFTS.

All the crank, line, thrust, and propeller-shafts will be of forged-steel. Each length will be forged solid in one piece, and will have a hole drilled axially through it from end to end.

All shafts will be finished all over. They will be supported as shown.

47. CRANK-SHAFTS.

There will be three sections of crank-shafts for each propelling-engine. Each section will have a crank of 21 inches throw, and will have a coupling-disc forged on each end, except the forward end of each high-press-

ure crank-shaft and the after end of the forward low-pressure crank-shaft. The coupling discs for the after engine will be 4 inches thick and 30½ inches diameter, and those for the forward engine 3 inches thick and 25½ inches diameter.

The length of each shaft for the after engine will be, for the high-pressure 8 feet 1¼ inches, for the intermediate pressure 9 feet 2 inches, and for the low-pressure 7 feet 2 inches. The length of each shaft for the forward engine will be, for the high-pressure 7 feet 3 inches, for the intermediate-pressure 9 feet 2 inches, and for the low-pressure 7 feet 7 inches.

There will be two journals on each section of shafting, one on each side of the crank, those for the after engine being 17 inches in diameter and those for the forward engine 13½ inches in diameter.

The crank-pins for the after engine will be 17 inches diameter and 14¼ inches long, and those for the forward engine 13½ inches diameter and 17 inches long.

The crank-webs for the after engine will each be 18½ inches wide and 11½ inches thick, and those for the forward engine 15 inches wide and 9 inches thick. The webs to be chamfered as shown in the drawings.

There will be a raised seating on each section of shafting for the eccentrics, and on the forward end of the after high-pressure and the after end of the forward low-pressure for the disengaging-coupling. The crank-pins must be accurately parallel to the main journals. All journals are to be smoothly and accurately turned, and when finished will be tested and their accuracy proved. There will be a hole 7½ and 6 inches in diameter bored axially through each shaft and crank-pin of the after and forward engines, respectively. When bolted together the cranks of each engine will be at angles of 120° to each other—the intermediate to follow the high-pressure and the low-pressure to follow the intermediate.

The forward end of the hole in each crank-pin will be closed by a brass plate fastened on with countersunk screws.

Two radial ½-inch holes will be drilled in each crank-pin from the outside to the bore.

The various lengths of the crank-shafts will be coupled to each other by forged-steel bolts. All holes in each coupling will be drilled or reamed to template. The bolts will be finished to fit the hole snugly, and each fitted with wrought-iron nut and split-pin.

A worm-wheel for turning the shaft will be fitted where directed.

48. DISENGAGING-COUPLING.

A cast-steel disengaging-coupling will be fitted on the crank-shafts between each set of engines in the same engine-room. It will be securely keyed to the shafts, and so fitted that the forward engines may be quickly and easily connected to or disconnected from the after engines. The coupling to be approved by the Bureau of Steam Engineering.

49. THRUST-SHAFTS.

They will be 16¾ inches in diameter, about 19 feet long over all, with 7½-inch axial holes. Each shaft will have 13 thrust-collars 2 inches wide, with spaces of 3¾ inches, the collars to be 21¾ inches outside diameter. There will be coupling-discs forged on the forward and after ends 3½ inches thick and 2 feet 7 inches diameter.

The bolt-holes in the couplings will be drilled or reamed to template, and will be spaced the same as those in the crank-shaft couplings.

50. PROPELLER-SHAFTS.

The propeller-shafts will each be in two sections, the forward section 16¾ inches diameter and about 38 feet 9 inches long over all; the after section will be 17 inches diameter and about 32 feet 6 inches long over all. The lengths of these shafts will be taken from the ship. A 7½-inch axial hole will be bored through each section, the hole being tapered where it passes through the propeller-hub.

The forward section will be fitted with a composition casing, shrunk and pinned on, and perfectly water-tight; the joints will lap over each other 1 inch. The forward and after ends of the casing will be tapered, and the shaft at the after end of the casing protected by a fillet of soft solder.

The inboard ends of the forward section of the propeller-shafts will be fitted with separate forged-steel coupling-discs, so that the shafts may be withdrawn from outboard.

The after ends of the forward sections and the forward ends of the after sections will have solid forged coupling-discs fitted as shown in the drawings.

The holes in the flanges for the coupling-bolts will all be drilled to the same template.

The after section of shafting will be cased with composition where it passes through the outboard bearing, the casing being in one length, shrunk, and pinned on.

The shaft will be protected at the forward end of the casing by a fillet of soft solder, the after end of the casings making a water-tight joint with the propeller-hub.

The shaft, couplings, and casings will be well coated with the same composition as the hull.

The shafts must extend inboard a sufficient distance to allow the inboard stern-bearings to be withdrawn without removing the coupling-discs.

51. LUBRICATION.

All working parts of the machinery will be fitted with efficient lubricators, each with a sufficient oil capacity for four hours' running. Each lubricator to be fitted with a tube leading to the wipers on the moving parts, or tubes in the bearings and guides. Each tube from the lubricators will be fitted with a valve adjustment and a sight-feed with a well-protected glass tube.

There will be in each engine-room for each engine a 5-gallon oil-tank, well tinned on the inside, and fitted with a glass gauge, filling-pipe, and air-cock. Each tank will be connected to all the lubricators on its engine by ½-inch brass or copper pipes, as may be directed, the

tank to be placed in such a position that oil will flow to each lubricator.

Unions will be fitted where necessary, so that the oil-pipes may be quickly taken down and cleaned, and each pipe will be connected to the bearings by a union-joint. Each main crank-pin will be oiled by cups carried on the cross-head, taking oil from wicks overhead; the oil to be carried to the crank-pins by brass pipes secured to the connecting-rods. These pipes will have union-joints where connected to oil-cups.

Each main cross-head journal will take oil from an overhead wick-cup.

Each cross-head guide will be oiled by pipes leading to about the middle of each forward and each backing-guide.

Pipes, fitted as above specified, will lead from the lubricators to the following parts of each engine: piston-rods, valve-stems, valve-links, and reversing-shaft bearings.

Each balance-piston and each piston-valve will have a globe oil-cup, placed sufficiently high to insure the oil running where desired without regard to the trim of the vessel.

The upper end of each eccentric-rod will carry a wiper oil-cup on each fork, these cups to take oil from wicks in cups easily adjusted to the various positions of the gear. The link-block pins will be lubricated by wiper oil-cups, fed from fixed cups overhead.

Each eccentric will have a long oil-cup fed by a drip-pipe, so arranged that the eccentric will be lubricated in all positions.

There will be a small oil-tank, with glass gauge, placed in a convenient position, and connected by pipes with a closed oil-box at each crank-shaft bearing so that, when necessary, oil can be supplied to the journals under a head. From each of these boxes three tubes will lead to the bearing, each with valve adjustment, and with a sight-feed with a well-protected glass tube.

The flexible couplings will be fitted with a centrifugal oiling apparatus, with a pipe leading to each bolt-head in the coupling-disc.

There will be fitted to each main steam-pipe, close to each high-pressure valve-chest, an approved steam sight-feed oil-cup of two quarts capacity, with gauge-glass. As far as possible all the oil for the moving parts of each engine, except main bearings, will be supplied from one oil-box on the cylinder, with separate valve, sight-feed, and pipe for each part to be oiled. There will be a steam sight-feed cup on each circulating, blowing feed, air-pump, and bilge-pump engine. Each blower-engine will have a continuous automatic lubricator of approved pattern. All working parts for which oil-cups are not specified or shown in drawings will have oiling-gear of approved design, such that they can be oiled without slowing. All the oiling of each auxiliary engine will be done by one oil-box where practicable. All fixed oil-cups will have hinged covers, with stops to prevent being opened too far. Moving oil-cups, where necessary, will have removable covers. The supply of oil to various parts is to be easily regulated. All oil-cups and their fittings, except such as are cast on bearings, will be of finished cast-brass, or of sheet-brass or copper, as may be directed, with all seams brazed.

52. OIL-DRIPS.

All fixed bearings will have drip-cups cast on where possible, otherwise they will be of cast-brass, properly applied. All moving parts will have drip-cups or pans cast on engine-frames where directed, otherwise to be substantially made of sheet-brass or copper, with brazed seams. All drip-cups will have drain-pipes and cocks of at least ½ inch diameter, which can be used while the engines are in operation.

53. JOURNAL-BOXES.

All journals or moving parts of iron or steel will run, unless otherwise specified, in composition boxes. These boxes will be lined with approved anti-friction metal where directed. All adjustable bearings will be provided with channel-brass chipping-pieces, securely held in place and easily removable.

54. MANDRELS FOR WHITE-METAL BEARINGS.

Hollow cast-iron mandrels will be furnished for forming the white-metal linings of crank-pin, crank-shaft, line-shaft, and thrust-bearings. All these will be smoothly and accurately turned to size, and packed so as to be perfectly protected.

55. STUFFING-BOXES.

All iron boxes will be bushed with composition. All glands will be of composition and fitted with approved means of adjustment while the engines are in operation, and those not fitted with pinion-nuts and spur-rings will have lock-nuts and split-pins. Metallic packing of approved kind, and subject to the approval of the Bureau of Steam Engineering, will be fitted in stuffing-boxes of all piston-rods and valve-stems of main and auxiliary engines. For piston-rods and valve-stems over 1¾ inches in diameter the packing will be in at least two independent sections; for piston-rods and valve-stems between ¾ and 1¾ inches diameter, it will be made in one section.

56. BOLTS AND NUTS.

All bolt-heads and nuts less than 2 inches, except in special cases, will conform to the United States Navy standard. Screw-threads on bolts and nuts must in all cases conform to the above standard. All finished bolts, except as directed, will be kept from turning by dowels or other suitable devices.

The nuts of all bolts on moving parts and on pillow-blocks, and elsewhere as shown, will be locked, and the bolts will extend beyond the nuts, without threads, and will be fitted with split-pins.

57. THRUST-BEARINGS.

Each thrust-bearing pedestal, of cast-iron, will be bored out to receive the lower part of bearing, and firmly bolted to the seating provided. The bearing will be in two parts, of cast-iron, with white-metal linings. The lower part will be finished to fit the pedestal. The upper part, or cap, will be separated from the bottom by composition

distance-pieces, and will be fitted in place with wrc iron dowel-pins, fitting snugly in holes in the lowe of bearing. The cap will be faced to fit longitu recesses in the upper flanges of pedestal, and w held down by bolts, body-bound in pedestal, but slotted holes in cap. Each cap will have a box c: top, with a hinged cover.

The end and side walls of the pedestal will for oil-trough, from which there will lead an oil-hole tc collar and each recess, the white-metal being prc channeled for distribution of oil. Inside this tr both forward and abaft the thrust-collars, will be a position bearing for taking the weight of the shaft. cap for this bearing will be of cast-iron lined with \ metal. These bearings will be adjustable vertica wedges with regulating-screws.

At each end of each thrust-bearing there will divided stuffing-box and gland to prevent escape At the bottom of each thrust-bearing there will fore-and-aft channel connecting all the bearing rec the connecting holes to be each of at least 1 squar(in area; a drain-cock will be fitted at each end.

The oil-trough will also be fitted with a coolin; There will be four adjusting-screws, two at each e the thrust-bearing pedestal, for adjusting the be fore and aft. The caps will be fitted with eye-bol convenience of handling.

58. JACKS FOR COUPLING-BOLTS.

A hydraulic jack of approved pattern will be fitt withdrawing the bolts of the shaft-couplings.

59. STERN-TUBE BEARINGS.

Each stern-tube will be finished as follows: It w made of mild steel with internal cast-steel rings at lignum-vitæ bearing. Fitted to these rings there w a composition bushing, the inner one made in halve joints to be in a horizontal plane when bushing place. These bushings will be fitted with sectic lignum-vitæ, put in so as to wear on end of grai

smoothly and accurately bored in place to suit the shaft-casing. All the lignum-vitæ bearings will be well water-soaked, and bored out in place to perfect alignment and to a loose fit on the shaft-casing.

60. STERN-TUBE STUFFING-BOXES.

At the forward end of each stern-tube there will be a composition stuffing-box, made in halves, divided longitudinally. It will be bolted to the flange on the forward end of the stern-tube bushing. The two parts will be bolted together along the longitudinal division by proper flanges. The follower will be of composition, in two parts, with a space of 1¼ inches between the parts on each side. The packing spaces will be about 7 inches deep and 1 inch wide.

The follower-bolts will be of rolled manganese or Tobin bronze. To each stuffing-box, abaft the packing, a 1½-inch pipe will be attached, leading to the engine-room bilge. It will also be connected with the engine-room water-service pipes, and will be provided with valves, so that the bearing can be drained into the bilge or washed out by water from the engine-room pump at will.

61. STERN-BRACKET BEARINGS.

Each stern-bracket bearing will have a neatly-fitting composition lining, made in halves, divided longitudinally. It will have a flange by which it will be secured to the forward end of the stern-bracket. It will have a lignum-vitæ bearing, fitted as in the stern-tube. The lignum-vitæ will be held in place at the after end by a flat ring bolted to the lining. A cast-steel sleeve will be secured to each stern-bracket by screws, to form a fair water-line to the propeller-boss. At the forward end of each bearing there will be a composition sleeve, secured to and supported by an extension of the lining before mentioned. This sleeve will be shaped to form a fair water-line from the shaft to the stern-bracket boss, and will be finished on the outside. The hole through the hanger will be of sufficient size to allow the forward section of the propeller-shaft to pass through it.

One for salt-feed pipe, 2 inches diameter, with a spray in the exhaust-passage;

One 2-inch nozzle, in hand-hole plate at bottom of condenser, for steam-pipe for boiling the water in condenser;

One hand-hole in the top of each tube-sheet, as shown, 7 inches by 12 inches.

One hand-hole at the bottom, 8 inches diameter, and one at each end in the tube-sheets 4 x 6 inches.

The vertical flanges of angles at ends of condenser will be made deeper at bottom and on side next to the bulkhead, as shown, for taking hold of supporting-saddles and brackets on bulkhead.

A stiffening-ring will be cast on each end of the middle section of each condenser, and one ring will be lengthened at the bottom, as shown, for attachment to saddles. The saddles at the ends of condenser will be made so as to fit snugly under the tube-sheets.

The condenser tube-sheets will be made of composition 1 inch thick, with smoothly-finished holes for the tubes, tapped and fitted with screw-glands for packing the tubes. The glands will be beaded at outer ends to prevent tubes from crawling, and will be slotted to admit a tool for screwing up. Cotton-tape packing will be used. There will be 3,775 seamless-drawn brass tubes in each condenser, $\frac{5}{8}$ inch outside diameter, No. 20 B. W. G. in thickness. The tubes will be 9 feet long between tube-sheets, and will be spaced $1\frac{5}{16}$ inch between centers. The cooling surface of each condenser will be about 5,559 square feet, measured on the outside of the tubes.

The sections of each condenser will be riveted together, as shown. All riveted seams will be tinned and soldered. The tube-sheets will be secured to the flanges of the shell by rolled manganese or Tobin bronze collar-bolts, which will also be used for fastening the circulating-water chests.

The chest for entrance and exit of circulating water will be cast of composition $\frac{7}{16}$ inch thick, with a division-plate in the middle and with a man-hole in each quadrant. There will be one inlet-nozzle, 14 inches diameter, and one outlet-nozzle 14 inches in diameter of opening.

The water-chest at the other end of the condenser will be cast of composition $\frac{7}{16}$ inch thick, as shown, with two 14-inch man-holes, and one 16 inches. There will be three stay-bolts in each head to connect the water-chests to the tube-sheets.

There will be four braces of rolled manganese or Tobin bronze connecting the tube-sheets, each $\frac{3}{4}$ inch in diameter, and each passing through a stay-tube about $1\frac{1}{2}$ inches external diameter and $\frac{1}{4}$ inch in thickness.

Baffle-plates of brass will be fitted, as shown, to direct the steam over all the tubes. Plates will be provided for supporting the tubes and to act also as baffle-plates.

In front of the main exhaust-nozzle, above the tubes, will be a deflecting-plate, supported as shown.

A copper tank, pipe, and cock will be provided for admitting an alkaline solution into the condenser—this pipe to connect with the salt-feed spray; the tank to be of at least 10 gallons capacity and conveniently placed. A 2-inch branch from the auxiliary steam-pipe will lead to the bottom of the condenser for cleaning the tubes by boiling.

Drain-cocks will be provided, with pipes leading to the bilge.

Each main condenser will be connected with the evaporators by a pipe and valve of approved size.

There will be a 3-inch spring safety-valve on the exhaust-pipe near the condenser, loaded to 25 pounds above atmosphere.

All parts of the condensers, except as otherwise specified, will be made of composition. All bolts will be made of rolled manganese or Tobin bronze. All bolts for securing flanges of pipes and man-hole plates will be standing-bolts, and will, wherever possible, be screwed into the condenser-plates, with heads inside. The condensers must be perfectly tight all over, and be so proved after being secured in place.

64. AUXILIARY CONDENSER.

Each engine-room will have an auxiliary condenser of sufficient capacity for one-half the auxiliary machinery,

each condenser being connected with all the auxiliary machinery. Each auxiliary condenser will be connected with the evaporators by a pipe and valve of approved size. The shell of the condenser will be made of sheet-brass or of composition, the heads and tube-plates of composition. The diameter and spacing of the tubes and the packing will be the same as used in the main condenser. It will have faced flanges for inlet and outlet of the condensing water, hand-hole plates, soda-cocks, drain-cocks, auxiliary exhaust-pipe, and pipe from evaporator.

65. AUXILIARY AIR AND CIRCULATING-PUMPS.

There will be a combined air and circulating-pump of approved size and type for each auxiliary condenser. The pump-cylinders, pistons, and rods will be of composition or bronze; all other working parts will be of wrought-iron or steel.

66. AIR-PUMPS.

There will be two single-acting, vertical air-pumps, driven by a two-cylinder, vertical, inverted simple engine for each propelling-engine.

Each steam-cylinder will be carried by two cast-steel frames supported upon brackets on the air-pump cylinders. Each of these frames will consist of two uprights of **T**-section, with bolting flanges at top and bottom, connected by webs of similar section. The crank-shaft bearings will be supported by two of the connecting webs.

There will be one engine-cylinder over each pump-cylinder. Each pump piston-rod will be secured to the cross-head by a **T**-head and two forged-steel bolts.

There will be one balance-wheel, placed between the two engines; it will be made in halves, and will be securely bolted together by forged-steel bolts.

The crank-shaft will have two bearings. The angle between the cranks will be 150°. All parts of the pumps, except where otherwise specified, will be made of composition. Each air-pump will have a piston working in a cylinder of 19 inches diameter. The pump-cylinders will be cast separate and bolted to a casing serving as founda-

tion, and containing the foot-valves. The delivery-valve chambers are cast in one with the pump-cylinders. The stroke will be 18 inches. The pump-pistons will be cast flanged, the flange being grooved for water-packing, as shown. The pump piston-rods will be made of rolled phosphor-bronze or approved equivalent metal. There will be eight foot-valves, six valves in each piston, and six delivery-valves for each pump, all 5 inches in diameter of opening in the valve-seats, and made of approved metal. Each valve will be held in place by a guard and a spiral spring of phosphor-bronze or approved equivalent metal. The valves and guards must be easily removable and held firmly in place. The valve-seatings for the delivery valves will be made separately from the pump-casings, and will be bolted in place.

The foot-valve seats will be placed in inclined positions at the bottoms of the pumps, and the delivery-valves horizontal at the highest parts of the pump-chambers. There must be no pockets in the pump-chambers underneath the delivery-valves, where vapor can lodge. The gratings of the valve-seats must be so arranged that the clear opening of each valve shall be at least 14 square inches. The bonnets will be well ribbed and provided with jack-bolts and eye-bolts. Each air-pump will have a suction-nozzle 9½ inches in diameter. A copper pipe will lead from the nozzle on the bottom of the condenser with a branch to each pump nozzle, and each pipe will have a straightway-valve at the condenser and in each branch pipe where it connects to the pumps. A 10½-inch discharge-pipe will lead from the delivery-valve chamber to the feed-tank.

The suction pipes from each air-pump will connect with both condensers in the same engine-room, and be fitted with straightway-valves so that each pump may draw from either condenser.

The pump-covers will be dished, made in halves, well ribbed, and bolted together by six forged-steel bolts.

The engine-cylinders will be 7½ inches in diameter. The cylinders, with their valve-chests, valve-chest covers, and slide-valves, will be made of cast-iron.

The pistons and cylinder-covers will be made of cast-iron.

The crank-shafts, piston-rods, valve-rods, and connecting-rods will be made of forged-steel. The pistons will be fitted with cast-iron packing-rings. The cross-heads will be of forged-steel, fitted with composition gibs, and will work between guides cast on the framing. The framing of the two engines will be tied together by two forged-steel cross-ties, and the framing of each engine will be tied together in the same manner.

The crank-shafts will be 3¾ inches diameter, with bearings 6 inches long at ends. Each crank-pin will be 3½ inches diameter and 3⅛ inches long, and recessed at each end, as shown on the drawings. Each cylinder will have a slide-valve, worked through gear as shown.

Each engine will take steam from a branch of the main steam-pipe, with a stop-valve having a hand-wheel at the working-platform, and will exhaust by a special pipe into the condenser, and there will also be pipes and valves through which it can exhaust into the intermediate and low-pressure receivers.

Each air-pump, together with its condenser, must maintain a vacuum of within four inches of mercury of the atmospheric barometer with the propelling-engines at full power under forced draught.

67. CIRCULATING-PUMPS.

There will be one centrifugal, double-inlet circulating-pump for each condenser, driven by independent engines of approved pattern, and of sufficient power to secure the results specified. The engine-valves will be of either the slide or piston type. Each pump must be capable of discharging 8,000 gallons of water per minute from the bilge. The pumps will be made of composition, except as otherwise specified. Each pump-casing will be made in two parts, divided in a horizontal plane, the upper part with conveniences for handling. The suction-nozzle will have an opening for sea-suction not less than 14 inches diameter, and a 14-inch opening for bilge-suction. The pump-runners will be smoothly cored,

finished on the outside, and perfectly balanced. The shafts will be of phosphor-bronze or other approved metal. The bearings will consist of sections of lignum-vitæ, on end of grain, dovetailed into composition split-sleeves, which will be well secured against turning. The stuffing-box glands will be each in two parts. There will be an air-cock at the top of the pump-casing and a drain-cock at the bottom. The pump-casings must be made as light as possible consistent with strength, and must be smoothly cored, with easy bends wherever the direction of the flow of water is changed.

68. CIRCULATING-PUMP CONNECTIONS.

Each circulating-pump will be fitted with pipes and valves to draw from the sea or engine-room bilge, and will deliver into the condenser—or direct to the outboard-delivery pipe by a pipe connecting inlet and outlet of condenser. This pipe and the inlet and outlet pipes of condenser each to have a straightway-valve.

The injection and delivery-pipes for condenser circulation will be not less than 14 inches internal diameter.

There will be stop-valves in the pipes leading from the sea and from the bilge to the circulating-pump in each engine compartment. These valves will be so connected by a locking device that when one is open the other is shut; and both will be worked by hand-wheels well above the floor-plates.

69. SEA-INJECTION VALVES.

There will be two straightway screw main injection-valves of not less than 14 inches diameter in each engine compartment, one for each condenser. Each will connect with the sea by a conical steel tube through the double-bottom.

There will be a strainer on each pipe at the ship's side. The hand-wheels of these valves must be easily accessible above the engine-room floor-plates.

There will be a 1½-inch steam-pipe leading from the auxiliary steam-pipe to the injection-pipe outside of injection-valve. This pipe to have a valve at each end.

70. BILGE-INJECTION VALVES.

They will be as specified under the head of "Bilge-suction Pipes."

71. OUTBOARD-DELIVERY VALVES.

There will be in each engine compartment two main outboard-delivery valves 14 inches diameter, of the same type as main injection-valves.

The valves in each compartment will connect with a steel pipe about ⅝ inch thick passing through the double-bottom. The hand-wheels will be accessible from the engine-room.

72. FEED-TANKS AND FILTER.

There will be a feed-tank for each engine-room, placed as shown in the drawing. Each tank will have a capacity of about 1,700 gallons. It will be made of ¼-inch wrought-iron. It will be braced internally as may be directed. Each tank will have at least 250 cubic inches of rolled-zinc plates, about ½ inch thick, suspended from the braces. The straps suspending the zinc plates and the braces where the straps come in contact will be filed bright before being secured in position. The parts to be then well painted on the outside, or the joints to be made water-tight in other approved manner. A portion of the tank will be fitted as a filter, in an approved manner, into which the water from the air-pumps will be delivered. The filter will be provided with sponges, or other approved material, and so arranged that it will be readily accessible. Each tank will have a man-hole with bolted cover, and will have a glass water-gauge with suitable guards, shut-off cocks, and drain-cocks.

Each tank and filter will have the following pipe-connections: A discharge-pipe from each air-pump in the same engine room; an over-flow-pipe leading to bilge, but so arranged that any water passing down it may be seen; a suction-pipe to feed-pumps, with valve; drain-pipes from traps, as elsewhere specified; a vapor-pipe, 3 inches diameter, of copper, No. 16 B. W. G. The vapor-pipe will lead up the engine-room hatch and discharge above the

level of the awnings, where it will have a suitable hood, or it may be led into the main escape-pipe. Each feed-pump suction will be provided with a balanced valve operated by a copper float in the feed-tank, so arranged that it will allow no air to enter the feed-pipes. All trap-discharges and drains will enter the feed-tanks well below the ordinary water-level.

73. GREASE EXTRACTOR.

Grease Extractors, to be approved by the Bureau of Steam Engineering, will be fitted where directed.

74. FEED-TANK SUCTION-PIPES.

A pipe will connect the feed-tanks in the port and starboard engine-rooms. From each tank there will be a suction-pipe for the main feed-pumps, and for the auxiliary feed-pumps in the fire-rooms, and a suction-pipe for the auxiliary feed-pump in the same engine-room.

Non-return valves will be fitted in the feed-pump suctions close to the pumps and straightway-valves at the tanks. The suction-pipes for the main feed-pumps will be connected by pipes and valves so that the pumps can take water from either tank. The suction-pipes for the auxiliary pumps will be connected in the same manner.

75. SUCTION-PIPES FROM BOTTOMS OF CONDENSERS.

From each air-pump channel-way below the foot-valves a 2-inch pipe will lead to the feed-pump suction-pipes, with a screw-down non-return valve.

76. SEA-SUCTION PIPES.

A pipe will lead from a sea-suction valve in each engine-room to the fire and bilge-pump, the auxiliary pump, and the auxiliary feed-pump in its compartment. A pipe will lead from a special sea-valve, fitted where directed, to the distiller circulating-pump. Each of these pipes will be of at least the same bore as the nozzle on the pump with which it connects. Each sea-suction will be controlled by a valve which will not permit sea-water to enter any of the bilge-suction pipes or feed-tank-suction pipes.

77. BILGE-SUCTION PIPES.

There will be the following suction-pipes from the bilge and from the drainage-pipes to the various pumps:

A 14-inch copper pipe will connect to each circulating-pump, with a stop-valve close to the pump, as before specified. This pipe will have two branches of such size as may be designated; of these one will connect with the main drainage-system, with a screw-down non-return valve which can be lifted from its seat by means of its stem; the other branch will connect directly with the bilge in its own compartment, and be fitted with a non-return valve which can be lifted from its seat by means of a sliding-stem, but without means of fastening it shut except by lashing the lever by which its stem is worked. This branch will be fitted with a Macomb or equivalent bilge-strainer of approved size.

There will be provided in each engine-room a manifold or suction-box, with the following connections, viz:

A 3-inch pipe leading from the lowest part of the compartment abaft the engine-room;

A pipe of the size of the combined areas of the suction-nozzles of the fire and bilge-pump, feed and auxiliary pump, from the secondary drain-pipe;

A pipe of the same size from the main drainage-cistern;

A pipe to the fire and bilge-pump in its own engine-room of the same size as the pump suction-nozzle;

A pipe to the auxiliary pump in its own engine-room of the same size as the pump suction-nozzle.

All these pipes will be provided with screw-down non-return valves.

Macomb or equivalent bilge-strainers will be inserted in the suction-pipes between the box and pumps.

There will be no other strainer or valves in any of these pipes other than those herein specified.

Each auxiliary feed-pump in the fire-rooms will have a suction-pipe of the full size of its suction-nozzle connected with the secondary drain-pipe. In addition to these the forward auxiliary feed-pumps will have a 3-inch suction from the lowest part of the bilge of the first compartment forward of the double-bottom. The suctions

to each pump will lead to a valve-box and strainer, fitted as before specified for the suctions to the fire and bilge-pumps. The lower ends of all bilge-suction pipes will be of galvanized-iron. Care will be taken that all the copper bilge-pipes are led sufficiently high to keep them out of the bilge-water under ordinary circumstances.

78. FIRE AND BILGE-PUMPS.

There will be in each engine-room a pump of approved design, which will be used as a fire and bilge-pump. It will have a capacity of 750 gallons per minute, with steam cylinder of suitable size to work as a fire-pump with steam of 60 pounds pressure. Each of these pumps will have suctions from the sea, the bilge of the compartment next abaft the engine-room, the secondary drain-pipe, and the drainage-cistern, the engine-room, and will deliver into the fire-main and overboard. In each of the auxiliary boiler fire-rooms there will be a wrecking pump of the same type and as the feed-pumps in the main fire-rooms and a capacity of 650 gallons per minute. It will have suctions from the drainage system and compartments as may be directed.

79. ENGINE-ROOM AUXILIARY PUMPS.

There will be in each engine-room the following auxiliary pumps, of approved pattern, with cylinders of proper proportion, to be used as fire-pumps with steam of 60 pounds pressure:

One of 750 gallons capacity per minute, with a suction from the sea, the bilge of the compartment next abaft the engine-room, the secondary drain-pipe, the drainage cistern and feed-tank, and to deliver into the main and auxiliary fore-and-aft feed-pipes, overboard, and the fire-main. There will be a straightway-screw check-valve in the discharge-pipe where it connects with the main and auxiliary fore-and-aft feed-pipes;

One of 220 gallons capacity per minute, with a suction from the sea only, and to deliver into the fire-main and water-service pipes.

80. ENGINE-ROOM WATER SERVICE.

There will be in each engine-room for each engine a 3-inch pipe connected with a sea-valve and with a special delivery from the auxiliary pump, with branches leading to the different parts of its engine, as follows:

A 1¼-inch branch connected by a union-joint with a pipe screwed into the cap of each crank-shaft bearing, and leading through brasses to top of journal;

Two 1¼-inch pipes to each crank-pin;

Two 1-inch pipes to each cross-head;

One 1-inch pipe to each go-ahead cross-head guide;

One 1-inch pipe to each pair of eccentrics;

One 1½-inch pipe to each thrust-bearing;

One 1-inch pipe to each line-shaft bearing;

One ½-inch pipe to each hollow brass or its equivalent in crank-shaft bearings;

Two 1-inch pipes to each air-pump engine and to each circulating-pump engine.

All of the above to have detachable sprays or short lengths of hose, as directed, and where directed to have pivoted nozzles.

Each branch will have a separate valve.

All the water-service pipes and fittings will be of brass; those above the floors will be polished. The pipes in the two engine-rooms will be connected with each other by a 4½-inch pipe and valve.

81. TURNING-ENGINES AND GEAR.

There will be in each engine-room a double engine of suitable size, to be approved by the Bureau of Steam Engineering, for turning the main engines with steam of 60 pounds pressure. This engine will drive by worm-gearing a second worm, which may be made at will to mesh with a worm-wheel on the propelling-shaft. The worm-wheel of each engine will be fitted where directed.

The turning-engine shaft will be squared at the end and fitted with a ratchet-wrench, of approved design, for turning by hand.

Each turning-engine will have piston-valves, and will be made reversible by means of a change-valve moved by a screw and hand-wheel.

The turning-wheels will be of cast-steel with cut teeth.

82. SECURING ENGINES IN VESSEL.

The engines will be adjusted and aligned upon the engine keelsons, and when accurately in line snugly-fitting wrought-iron washers will be fitted around all holding-down bolts. The holding-down bolts will be firmly set up and bolts and nuts locked in place.

When finally secured all shafting must be accurately in line with the vessel at load-draught and ordinary stowage.

All parts of machinery and boilers will be secured in an approved manner to prevent displacement when the vessel is used for ramming.

83. STEAM AND VACUUM-GAUGES.

There will be the following gauges, in polished brass cases, suitably engraved to show to what they are connected—all to be of approved pattern and equal to "Lane's improved," with seamless tubes:

One on each single-ended boiler;

Two on each double-ended boiler, one at each end;

One connected to each main steam-pipe in the engine-room;

One connected to each intermediate valve-chest;

One connected to each low-pressure valve-chest;

One connected to each condenser.

All the above will have 8½-inch dials—those in engine-room to be at the working-platform.

Also the following with 4½-inch dials:

One connected to each intermediate-pressure cylinder-jacket;

One connected to each low-pressure cylinder-jacket;

One on each auxiliary steam-pipe in each engine-room and each fire-room;

One on each circuit of radiator-pipes near the reducing-valve.

The gauges on valve-chests and steam-jackets will be plainly marked with the limit of pressure permissible.

The gauges on intermediate and low-pressure valve-chests will indicate both pressure and vacuum.

A mercurial vacuum-gauge will be connected to each condenser.

In addition to the above there will be a 4½-inch steam-gauge at each hydraulic pumping-engine, one on each hydraulic main, and such as are elsewhere specified.

84. THERMOMETERS.

There will be the following thermometers—all to be permanent fixtures, with their stems and bulbs protected by brass covers; the casings and fittings to be of polished brass:

One on each hot-well;
One on each feed-tank;
One on each main feed-pipe in fire-rooms;
One on each main injection-pipe;
One on each main outboard-delivery pipe;
One on each main steam-pipe close to engine.

The hot-well and feed thermometers will be so fitted as to waste no feed-water.

There will also be furnished:

Four spare water-thermometers complete;
Six spare steam-thermometers complete;

Two standardized thermometers, graduated on stem and reading to $\frac{1}{10}$ degree Fahrenheit; stems to be at least 20 inches long; each thermometer to be in a rubber-lined brass case, and each case to be suspended by springs in a suitable permanent locked case in engine-room. These thermometers must be equal to the best in the market, subject to the approval of the Bureau of Steam Engineering, and be accompanied by certificates of standardization.

85. REVOLUTION-COUNTERS.

They will be of an approved type, to register from 1 to 1,000,000, each worked by positive motion; each to be in a polished brass case. There will be fitted:

One for each main engine;
One for each air-pump;
One for each circulating-pump.

86. REVOLUTION-INDICATORS.

They will be of such approved pattern as shall not be affected to a perceptible degree by the motion of the ship or by changes of temperature. They must be worked off the engines by positive motions, and must be so fitted that changes of engine speed shall not produce violent fluctuations of the indices. There will be two in each engine-room—one to show the speed of each propeller.

Approved tell-tales, to be approved by the Bureau of Steam Engineering, will be fitted on the bridge and in the conning-tower, to show the direction of the revolution of the main engines.

87. ENGINE-ROOM TELEGRAPHS.

A repeating-telegraph of approved pattern will be fitted in each engine-room with its dial at the working-platform, and connected to transmitters in conning-tower, in wheel-house, and on bridge. The connections are to be made in such manner that the chance of derangement shall be minimized.

88. SPEAKING-TUBES.

They will be made of copper not less than No. 20 B. W. G. They will connect each engine-room with each fire-room; the engine-rooms with each other; the fire-rooms with each other; each engine-room to the pilot-house, conning-tower, bridge, and to the chief engineer's room; each fire-room with the upper deck close to the top of the ash-hoist, and elsewhere as required. Each tube will be fitted at each end with a mouth-piece and approved annunciator—the mouth-pieces to be connected to short flexible pipes where required. All mouth-pieces or pipes will be plainly marked. The tubes will be suitably cased where necessary.

89. ENGINE-INDICATORS.

An indicator connection will be made to each end of each cylinder of main engines, and to each end of each steam and water-cylinder of each air-pump as near as possible to the bore of the cylinder, and so as to be easily ac-

cessible. Each indicator on the cylinders of main engines, when in place, will be connected to but one end of a cylinder. The connecting pipes will be 1-inch bore, with easy bends. The indicator-motion of each engine and air-pump will be so fitted that both indicators on its cylinder can be connected at the same time. The motions of the indicator-barrels must be accurately coincident with the motion of the corresponding pistons, and such as to give a motion of not less than 4 inches. The steam-cylinders of all auxiliary engines will have holes tapped for indicator-fittings, and then plugged. These engines will have portable indicator-motions fitted, then removed and suitably marked and stowed. Where auxiliary engines are duplicated but one set of indicator-motion fittings need be supplied for all of each kind.

Eight indicators will be furnished for each engine-room: two for the high-pressure cylinder, with four springs of such scales as may be directed; two for the intermediate-pressure cylinder, with four springs of such scales as may be directed; two for the low-pressure cylinder, with four springs of such scales as may be directed; and two indicators for auxiliary engines, each with four springs of such scales as may be directed.

The indicators will be the best in the market, subject to the approval of the Bureau of Steam Engineering, with detent-motion and with adjustable tension to the barrel-spring. They will be nickel-plated, and will be complete with all attachments. One extra cock-attachment will be furnished with each indicator. Each indicator will be in a separate locked case, each case to be suitably marked on a brass plate, and each case to be conveniently stowed.

90. ENGINE-ROOM DESKS.

A black-walnut desk of approved pattern, with locked drawers, and with a locked cabinet of pigeon-holes, will be fitted in each engine-room where directed.

91. CLOCKS.

There will be in each engine-room, close to the counter in a polished brass case, an eight-day clock, with 8½-inch

dial and a second-hand. The pattern and movement to be approved by the Bureau of Steam Engineering.

There will be in each fire-room a similar clock, with an outer dust-tight case with heavy plate-glass.

92. BOILERS.

There will be six double-ended main boilers and two single-ended auxiliary boilers of the horizontal return-fire tube type, all to be made of steel. The main boilers will be about 15 feet 3 inches outside diameter and about 21 feet 3 inches long. The auxiliary boilers will be about 10 feet mean diameter and 8 feet 6 inches long. They will have for the double-ended boilers about 31,190 square feet of heating surface and about 988 square feet of grate surface. The auxiliary boilers will have a total of about 1,937 square feet of heating surface and about 64 square feet of grate surface. Each double-ended boiler will have eight corrugated furnace-flues 3 feet 3 inches internal diameter, and each auxiliary boiler will have two corrugated furnace-flues 2 feet 9 inches internal diameter.

93. BOILER MATERIAL.

All plates used in the construction of the boilers will be open-hearth steel. The rivets will be of open-hearth or Clapp-Griffiths' steel. All material will be tested, as elsewhere specified.

94. BOILER-SHELLS.

For the main boilers they will be made of $1\frac{19}{64}$-inch plates—the shell of each boiler to be made in three courses and each course of three plates. The shells of the auxiliary boilers will be made of $\frac{57}{64}$-inch plates, each shell to be made in two courses, and each course of two plates.

95. BOILER-HEADS.

Both heads of the double-ended boilers will be made of three plates. The upper plate will be $1\frac{19}{64}$ inches thick, the middle plate $\frac{7}{8}$ inch thick, and the bottom plate $\frac{3}{4}$

inch thick. The heads of the auxiliary boilers will be made of two plates; the upper plate will be $\frac{57}{64}$ inch thick and the lower plate $\frac{3}{4}$ inch thick.

The upper plate of each head of the main boilers will be curved back to a radius of about 3 feet $10\frac{3}{8}$ inches, and those of the auxiliary boilers to a radius of about 2 feet $2\frac{1}{2}$ inches.

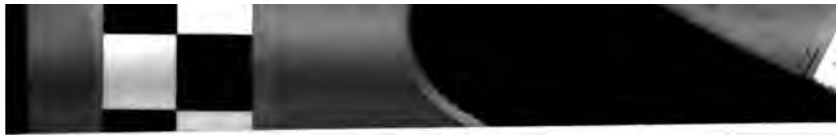
The heads of the double-ended boilers will be flanged outwardly at the furnaces and inwardly at the circumference, and those of the auxiliary boilers will be flanged inwardly at the furnaces and circumferences. The heads will be stiffened by T-bars, as shown on the drawings.

96. BOILER-TUBE SHEETS.

For the main boilers they will be $\frac{7}{8}$ inch thick at the front and $\frac{3}{4}$ inch thick at the back, and for the auxiliary boiler they will be $\frac{3}{4}$ inch thick at the front and back. Each pair of tube-sheets must be accurately parallel. All tube-holes will be slightly rounded at the edges. The holes for stay-tubes will be tapped in place. The holes at combustion-chamber end will be drilled to suit the protection of tubes, as specified below.

97. BOILER-TUBES.

They will be of steel, lap-welded and drawn, the best that can be obtained in the market, and subject to the approval of the Bureau of Steam Engineering. All tubes for the main boilers will be $2\frac{1}{4}$ inches, and those for the auxiliary boilers $2\frac{1}{2}$ inches external diameter. The ordinary tubes will be No. 12 B. W. G. in thickness, and will be swelled to $2\frac{5}{16}$ inches and $2\frac{9}{16}$ inches external diameter at the front ends for the main and auxiliary boilers respectively. The back ends will be expanded in the tube-sheet, beaded over into a counter-bore, which will be filled with a ring, or they will be protected from the action of the flame in other approved manner. The method of protection must be such as will not interfere with the use of ferrules, will not cause injury to the tube-sheet when tubes are cut out, and will not reduce the area through the tubes.



The stay-tubes will be No. 6 B. W. G. in thickness. They will be reinforced at both ends to an external diameter of 2⅜ and 2⅝ inches for the main and auxiliary boilers respectively, leaving the bore of the tube uniform from end to end. They will then be swelled at the front ends to 2½ inches and 2¾ inches external diameter, for the main and auxiliary boilers respectively. They will be threaded parallel at combustion-chamber ends, and taper at front ends to fit threads in tube-sheets. They will be screwed into the tube-sheets to a tight joint at the front ends, and will be made tight at the back ends by expanding and beading. All expanding will be done by approved tools. Cast-iron ferrules of 1½ inches internal diameter will be used to protect the ends of stay-tubes in combustion-chambers. All tubes of the main boilers will be spaced 3¼ inches from center to center vertically, and 3½ inches horizontally; those of the auxiliary boiler will be spaced 3½ inches vertically, and 3¾ inches horizontally.

98. COMBUSTION-CHAMBERS.

There will be four combustion-chambers in each double-ended boiler and two in each auxiliary boiler. The combustion-chambers for the main boilers will be arranged so that there will be one combustion-chamber for each two adjacent furnaces at the same end of the boiler. They will be made of ½-inch plates, except the tube-sheets, which will be as before specified. The tops of the combustion-chambers will be braced by girders, as shown. The plates will be flanged where necessary, and all parts joined by single-riveting. The holes for screw stay-bolts in plates of combustion-chambers and shells will be drilled and tapped together in place.

99. BOILER BRACING.

The bracing will be as shown in drawings.

The combustion-chambers will be stayed to each other and to the shell of the boiler by screw-stays, screwed into both sheets and fitted with nuts—the nuts to be set up on beveled washers where stays do not come square with the

plates. The holes for screw-stays will be tapped in both sheets in place.

The bottoms of the combustion-chambers will be stiffened by angles.

All screw-stays and all screwed braces will have raised threads.

All braces will be made without welds.

In boiler-braces fitted with eyes care must be taken that the sectional area through the neck or eye is not less than that of the cylindrical portion.

100. RIVETED JOINTS.

For the double-ended boilers the logitudinal joints of boiler-shells will be butted, with 1-inch straps inside and outside, and treble-riveted, as shown on the drawings. Joints of heads with shells will be double-riveted; all other circumferential joints will be lapped and treble riveted. Joints in furnaces and combustion-chambers will be single-riveted. For the auxiliary boilers the longitudinal joints of boiler-shells will be butted with $\frac{15}{32}$-inch straps inside and outside, and treble-riveted, as shown on the drawings. Circumferential joints will be lapped and double-riveted, and joints in furnaces and combustion-chambers will be single-riveted. Rivets will be of Clapp-Griffith steel. Edges of all plates in cylindrical shells, and of all flat plates where not flanged, will be planed. Edges of flanges will be faired by chipping or otherwise, as may be approved. Plates in cylindrical shells must not be sheared nearer the finished edge than one-half the thickness of the plate along the circumferential seams, and not nearer than one thickness along the longitudinal seams. No plate must average less than the specified thickness along the longitudinal seams. All rivet-holes in shell-plates will be drilled in place after bending. Hydraulic riveting will be used wherever possible. In parts where hydraulic riveting cannot be used, the rivet-holes will be coned and conical rivets used. Seams will be calked on both sides in an approved manner. Longitudinal seams will break joints. All joints will be as shown on drawings.

101. BOILER MAN-HOLES AND HAND-HOLES.

There will be man-holes in each boiler, placed, and of such size, as shown in drawing.

Man-holes without stiffening-rings will have cast-steel or wrought-iron yokes, which will take the place of dogs, and will have a bearing on the plate all around the man-hole. The upper man-hole will have a raised cast-steel frame flanged and riveted to the inside of the shell of the boiler, as shown.

The man-hole covers will be of mild steel and stamped in dished form. All man-hole plates will be secured by two wrought-iron dogs and two 1¼-inch studs with square nuts. Each plate will have a convenient handle.

All plates, yokes, dogs, and nuts will be indelibly marked to show to what holes they belong.

102. FURNACES.

Each furnace for the main boilers will be in one piece, $\frac{17}{32}$ inch thick, and corrugated, 3 feet 3 inches least internal diameter and 3 feet 7 inches greatest external diameter; and each furnace for the auxiliary boilers will be in one piece, $\frac{15}{32}$ inch thick and corrugated, 2 feet 9 inches least internal diameter and 3 feet 1 inch greatest external diameter. They must be perfectly circular in cross-section at all points. They will be riveted to flanges of front heads, and will be flanged and riveted to combustion-chamber plates. The corrugations of adjacent furnaces will be made to alternate.

103. GRATE-BARS AND BEARERS.

The grate-bars will be of wrought-iron, of approved shaking pattern. They will be so fitted that they can be readily worked under forced draft without opening the furnace or ash-pit doors, and without allowing an escape of air or gases. They will also be so fitted as to be readily removed and replaced without hauling fires. The bars at sides of furnaces will be made of cast-iron to fit the corrugations. The bearers will be made of wrought-iron, supported by wrought-iron lugs bolted to the furnace-flues, and perforated so as to allow the air to reach all parts of the grate-bars.

104. BRIDGE-WALLS.

They will be made of cast-iron, so fitted as to be readily removable. They will extend back to the back of combustion-chambers so as to leave no place behind them where dirt can accumulate. They will be finished with fire-brick or other approved refractory material.

105. FURNACE-FRONTS.

They will be made with double walls of wrought-iron, bolted to a light frame. The space between the two walls will be in communication with the ash-pits. The upper part of the inner plate of furnace-front will be perforated as directed. The dead-plates will be made of cast-iron, and fitted so as to be easily removed and replaced. The door-openings will be as large as practicable. There will be a beading on the inside of the door-frame in wake of the inner plate of door to make the clearance as small as possible.

106. FURNACE-DOORS.

The furnace-doors must be protected in an approved manner from the heat of the fire. There will be three hinges to each door, all of wrought-iron; the upper hinge will be so made as to support the weight of the free end of the door, and so fitted that the sag can be easily taken up. The latches will be of wrought-iron. Drawings showing the arrangement of furnace-fronts and furnace-doors must be submitted to the Bureau of Steam Engineering before work is commenced on them.

107. AIR-DUCTS.

Air-ducts as shown on the drawings will be fitted to supply air for the fire-room blowers. Hoods or screens must be fitted so as to prevent the hot air arising through the fire-room hatches being drawn down the ducts leading to the blowers. Each air-duct leading to a blower will be fitted with a damper, which can be easily and quickly closed in case its blower is stopped. The ducts will be constructed of iron or steel plates not less than $\frac{3}{16}$ inch thick.

108. ASH-PIT DOORS.

They will be made of ⅛-inch wrought-iron, stiffened with angle or channel-iron. Each door will have two wrought-iron handles, two wrought-iron beckets to fit hooks on uptake-doors, and an eye for slinging by.

109. LAZY-BARS.

A lazy-bar with the necessary lugs will be fitted in the front of each ash-pit. Also portable lazy-bars for the furnaces.

110. ASH-PANS.

Ash-pans of ¼-inch wrought-iron, reaching from the front of furnace-flue to bridge-wall, will be fitted to all furnaces.

111. CIRCULATING-PLATES.

Each boiler will have circulating-plates fitted at each side of each nest of tubes. They will be of steel, ⅛ inch thick, in sections, so as to be easily introduced and removed through man-holes. Each section will have two clips at upper and one at lower end for supporting it from the stay-tubes. The plates will be well painted all over with two coats of approved paint or cement.

112. UPTAKES.

They will be made of wrought-iron, No. 8 B. W. G., built on channel-iron and stiffened with angle-irons, and will be bolted to boiler-heads and shells. They will be bolted to the lower plates of smoke-pipe, with slotted holes to allow for expansion.

The uptakes from each boiler will be kept separate below the armor-bars.

Outside of the uptakes will be a jacket inclosing a 3-inch air-space; this jacket will be made of No. 12 B. W. G. iron, and will extend from the tops of uptake-doors to the tops of the uptakes. Above the water line of the boilers the uptakes must be carried up clear of the boiler-fronts.

The space between the plates of the uptakes will be filled with an approved incombustible non-conducting material.

113. UPTAKE-DOORS.

The uptake-doors will be made of double shells of iron of the same thickness as uptakes. The space between the shells will be filled with the same non-conducting material as in uptakes.

The hinges and latches will be made of cast-steel or wrought-iron. Each door will have two hooks for hanging the ash-pit doors, and a hook for a rope for hoisting the same.

Each door will also have an eye near its top for handling.

114. SMOKE-PIPES.

There will be two smoke-pipes, about 55 feet in height above the grates of the lower furnaces. The lower parts of the pipes will be shaped to connect with the uptakes, and will be built of No. 7 B. W. G. iron or steel. The upper part of the smoke-pipes will be oval in cross-section, built of No. 9 B. W. G. iron or steel. The flat sides of the oval part will be strengthened by cross-stays riveted to angles. The pipes will be well stiffened by angles.

The pipes will be finished at the top by angle-irons, to which the stay-shackles will be secured, and by a hood covering the casing, to which will be secured shackles for slinging painters. The pipes will be strongly stayed by guys and turnbuckles of approved dimensions and pattern. All joints will be butted and strapped. The pipes will be supported in an approved manner, so that their weight will not come on the uptakes.

From its junction with the uptakes to about 6 inches below the hood at top the smoke-pipes will be surrounded by a casing, leaving an annular space of 3 inches. The casing will be made of iron, No. 12 B. W. G., and strengthened by angle-irons. It will be butted and strapped, flush-riveted on the outside, and open top and bottom.

It will be stayed to the pipes, and will be finished with a half-round iron at top. There will be doors through this casing and through smoke-pipes about on a level with the main deck.

Above the smoke-pipe hatches an iron casing, No. 12 B. W. G., leaving an annular space of about 6 inches, will extend for about 5 feet, and will be finished by half-round iron. About 1 foot above this there will be a hood carried by the smoke-pipe casing.

There will be a ladder on the outside of each pipe, on the forward side, reaching to the top; this ladder to be made of round iron, bent and riveted to the pipe.

115. SMOKE-PIPE COVERS.

The smoke-pipes will have permanently-fixed covers made of wrought-iron, No. 11 B. W. G., built on angles in a slightly dished form and supported by angles riveted to the smoke-pipes. The covers will be placed at such a height above the top of the smoke-pipes so that they will not interfere with the escape of the gases, and will overlap the smoke-pipes about 18 inches all around.

116. BOILER-SADDLES.

Each double-ended boiler will rest in five saddles and each auxiliary boiler in two saddles. Angle-irons will be riveted to the boilers to fit the saddles. The angle-irons will be bolted to the saddles with allowance for expansion.

117. BOILER ATTACHMENTS.

Each boiler will have the following attachments, viz:

One steam stop-valve;

One dry-pipe;

One main feed check-valve with internal pipe;

One auxiliary feed check-valve with internal pipe;

One bottom-blow valve with internal pipe;

One surface-blow valve with internal pipe and scum-pan;

Two safety-valves to be connected with dry pipe or have internal pipes;

One steam-gauge on each single-ended boiler, and one at each end of each double-ended boiler;

Two glass water-gauges of approved automatic-closing pattern on each single-ended boiler, and two at the feeding and one at the other end of each double-ended boiler;

Four gauge-cocks on each single-ended boiler, and four at each end of each double-ended boiler;

One sentinel-valve;

One salinometer-pot;

One drain-cock;

One air-cock;

One approved circulating apparatus;

One cock with thread for the attachment of a syringe.

All external fittings will be of composition unless otherwise directed. All fittings will be flanged and through-bolted or attached in other approved manner. All cocks, valves, and pipes will have spigots or nipples passing through the boiler-plates. All internal pipes will be of brass, No. 14 B. W. G., and must touch the plates nowhere except where they connect with their external fittings. The internal feed and blow-pipes will be expanded in the holes in boiler-shells to fit the nipples on their valves, and they will be supported where necessary in an approved manner. The stems of all valves on boilers are to have outside screw-threads. The internal feed and blow-pipes are to be arranged to come between the corrugations of furnaces.

118. BOILER MAIN STOP-VALVES.

There will be a 10-inch self-closing stop-valve, with horizontal spindle, on each double-ended boiler, and one 5 inches diameter on each auxiliary boiler. There will be a 7-inch nozzle on each valve-chamber of the double-ended boilers for attachment of the auxiliary stop-valve.

A screw-sleeve, with suitable hand-wheel, will be fitted for closing the valve; also a spindle and handle for opening the valve.

The stop-valves on all the boilers will be located as directed.

The wheels on all boiler stop-valves will have rims covered with wood.

119. BOILER AUXILIARY STOP-VALVES.

There will be on each of the double-ended boilers a 7-inch self-closing stop-valve, with horizontal spindle bolted to a nozzle on the main stop-valve chamber.

120. DRY-PIPES.

There will be in each boiler, as high as possible and properly supported, a brass or tinned copper dry-pipe, extending nearly the length of the boiler, perforated on its upper side with longitudinal slits of such a number and size that the sum of their areas will equal seven-eighths of the area of the stop-valve. The pipes will be 10 and 5 inches diameter respectively, for the double-ended boiler and auxiliary boilers.

121. FEED CHECK-VALVES.

The main and auxiliary check-valves on the double-ended boilers will each be 4½ inches in diameter, and on the auxiliary boilers 2½ inches diameter. They will be placed on the shell at front ends of the boilers, but entirely separate from each other, and will be fitted with internal pipes, the main feed-pipes leading above the tubes and pointing downward in the water-spaces between the nests of the tubes and between one of the wing-nests and shell, as shown. The auxiliary internal feed-pipe will lead in a similar manner on the other side of the boiler.

The valve-cases will be so made that the bottom of the outlet-nozzle shall be at least ½ inch above the valve-seat. The valves will be assisted in closing by phosphor-bronze spiral springs. These valves will have polished brass bent bar-handles in lieu of hand-wheels.

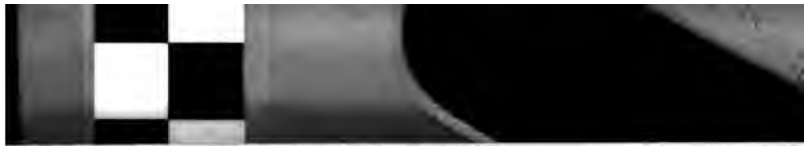
122. SAFETY-VALVES.

Each double-ended boiler will have two 7-inch and each auxiliary boiler two 3-inch spring safety-valves, placed on the stop-valve casings; the two valves to be in one

case. Each valve will have a projecting lip and an adjustable ring for increasing the pressure on the valve when lifted, or an equivalent device for attaining the same result. They will be adjustable for pressure up to the test pressure—the adjusting mechanism to have an index to show the pressure at which the valve is set, and a lock to prevent tampering with the adjustment. The locks on all safety-valves will be alike. The springs will be square in cross-section, of first quality of tool-steel, and will be nickel-plated. They will be of such a length as to allow the valves to lift one-eighth of their diameters when the valves are set at 160 pounds pressure. They will have spherical bearings at ends, or be connected to the compression-plates in such a manner as to insure a proper distribution of pressure. They will be inclosed in cases so arranged that steam will not come in contact with the springs. The spring-cases will be so fitted that the valves can be removed without slacking the springs. The valve-stems will fit loosely in valves, to bottom below the level of the seats, and to be so secured that the valves may be turned by a wrench or cross-bar on top of stem. The valves will be guided by wings below and in an approved manner above. The valves will be fitted with mechanism for lifting by hand from main deck and fire-rooms—the mechanism for each pair of valves to be such that the valves will be lifted in succession. All joints in the lifting-gear will be composition-bushed. The outlet nozzle will be in the base casting, so that the joint at the escape-pipe will not have to be broken when taking the valves out. The casings, valves, and spindles will be made of composition. The valve-seats will be of nickel, or equivalent metal of approved kind. A drain-pipe will be attached to each safety-valve casing below the level of the valve-seats, leading to the bilge.

123. SENTINEL-VALVES.

Each boiler will have a sentinel-valve of ½ square inch area. It will have a sliding weight on a notched lever graduated to 170 pounds pressure, and will be placed at the same end of the boilers as the check-valves.



124. BOTTOM BLOW-VALVES.

There will be a 2½-inch bottom blow-valve on each boiler, bolted to the shell near the front. The valves will close with the boiler-pressure. An internal pipe will lead from each valve to near the bottom of the boiler.

125. SURFACE BLOW-VALVES.

There will be a 2-inch surface blow-valve on each boiler, bolted on or near the front. The boiler pressure will be above the valve. An internal pipe will lead from each valve to near the water line in the boiler, and will be fitted with a scum-pan. The valve-casing and hand-wheel, will be of composition.

126. BLOW-PIPES.

A 3-inch pipe will connect with all bottom blow-valves in each compartment and with a sea-valve in the same compartment. This pipe will have a nozzle for the connection of a pipe for pumping out the boilers, as well as 2-inch nozzles for attachment of pipes from the surface blow-valves. There will be a straightway-valve in the blow-pipe as near the sea-valve as possible. All joints will be flange-joints.

127. BOILER PUMPING-OUT PIPES.

A 3-inch pipe will connect the bottom blow-pipe in each compartment with one of the auxiliary feed-pumps, with a screw stop-valve above the floor near the pump.

128. STEAM-GAUGES.

There will be a spring steam-gauge on each auxiliary boiler and one at each end of each double-ended boiler. The gauges will have seamless tubes and 8½-inch dials, graduated to 255 pounds, and will be equal to "Lanc's improved." This gauge will have an independent connection with the boiler and be fitted with a three-way cock, a drain-cock at the lowest part of the steam-pipe from the boiler, and a coupling for attachment of a test-gauge.

129. BOILER WATER-GAUGES.

Each auxiliary boiler will have two glass water-gauges, and each double-ended boiler will have two glass water-gauges at the feeding and one at the other end, and all to be of approved automatic-closing pattern. Each gauge will be placed at the side of the boiler and will have 1½-inch pipes leading to top and to near bottom of boiler, with a valve in each close to boiler, the two gauges at the same end being placed on opposite sides and as far apart as possible. The shut-off and blow-out cocks are each to have at least ½ inch clear opening, and will be packed cocks, with levers and rods for working from fire-room. The glasses will be about 16 inches in exposed length, with the lowest exposed part about 1 inch above the highest heating surface. The glasses will be well protected. A brass index-plate, with letters and arrows cast in relief, will be fixed close to each gauge-glass to show the height of the top of combustion-chamber. The blow-out cocks will have drain-pipes leading to bilge, with union-joints.

130. GAUGE-COCKS.

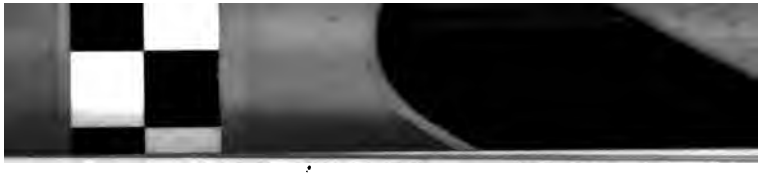
There will be four asbestos-packed gauge-cocks of approved pattern on each single-ended boiler and four at each end of each double-ended boiler, with rods and levers for working from fire-room. Each cock will have an independent attachment to the boiler. They will be spaced about 6 inches vertically, the lowest one being about 4 inches below the highest heating surface. Each set of cocks will have a drip-pan and a 1-inch drain-pipe leading to bilge.

131. SALINOMETER-POTS.

There will be a salinometer-pot of approved pattern connected to each boiler. They will be placed in groups in the fire-rooms where directed.

132. BOILER DRAIN-COCKS.

Each boiler will have a 1-inch drain-cock of approved pattern.



133. BOILER AIR-COCKS.

Each main boiler will have a ½-inch air-cock at its highest part, with a ½-inch copper pipe leading to bilge.

134. CIRCULATING APPARATUS.

There will be fitted to each boiler an approved device for circulating the water in the boiler while raising steam. Each of these will be fitted where directed and have a stop-valve close to boiler. They will take steam from the auxiliary steam-pipe, with stop-valve in fire-room.

135. ZINC BOILER-PROTECTORS.

Each boiler will have rolled-zinc plates 12 x 6 x ½ inch. Each plate will be bolted to wrought-iron straps, which will be clamped to the stays. Each strap will be filed bright where in contact with zinc and stay, each stay being also filed bright at contact point. After being bolted in place the outside of the joints will be made water-tight by paint or approved cement. The zinc plates will be located as may be designated by the Bureau of Steam Engineering.

136. MAIN FEED-PUMPS.

There will be in each fire-room in which the check-valves are placed two vertical pumps of approved pattern, with packed pistons or packed plungers for main feed-pumps. Each will have water-cylinders of sufficient capacity to deliver 325 gallons of water per minute for the double-ended boilers and 150 gallons per minute for the auxiliary boilers. The water-valves will be metallic, of approved kind. The pumps will be so arranged that the packing of the water-pistons will be easily accessible. The steam-cylinder must be of sufficient size to work the pump at the required speed to supply the water above required. The exhaust-cushion must be adjustable. The water-cylinders, pistons, and pump-rods will be of composition or bronze, and all other working parts will be of wrought-iron or steel.

Each main feed-pump will draw water from the feed-tanks only, and deliver into main feed-pipe only.

The main feed-pumps for the auxiliary boilers will be placed above the armored deck in the same compartment as the boilers, and they must be so arranged that they will draw water from the feed-tanks under all circumstances.

137. AUXILIARY FEED-PUMPS.

There will be in each fire-room in which the check-valves are placed two vertical auxiliary feed-pumps of approved pattern, with packed pistons or packed plungers. Each will have water-cylinders of sufficient capacity to deliver 325 gallons of water per minute for the double-ended boilers and 150 gallons per minute for the auxiliary boilers. Each will be connected to draw from the sea, feed-tank bilge, or boilers at will, and to deliver either into auxiliary feed-pipe, fire-main, or overboard through the outboard delivery in its own compartment. The water-cylinders, pistons, and pump-rods will be composition or bronze, and all other working parts will be of wrought-iron or steel. In each engine-room there will be one auxiliary feed-pump of 750 gallons capacity per minute, as specified under engine-room auxiliary pumps.

These pumps will have steam-cylinders adapted for use as fire-pumps with steam of 60 pounds pressure. The auxiliary feed-pumps for the auxiliary boilers will be fitted the same as the main feed-pumps for these boilers.

138. FEED-PUMP PRESSURE-GAUGES.

Each main and auxiliary feed-pump will have a spring-pressure gauge registering from zero to at least 300 pounds per square inch.

139. ASH-HOISTS.

One ventilator in each fire-room will have vertical guide-strips of iron on the inside, and be fitted with all the necessary gear for hoisting ashes.

An ash-hoisting engine of approved design will be fitted in each fire-room hatch or such place as may be directed, of sufficient power to hoist 300 pounds from the fire-room floor to the deck in five seconds with steam of 60 pounds pressure.

It will have a reversing-gear, to be worked from the fire-room and from deck, with approved adjustable safety-gear to prevent overwinding and to stop the engine when the ash-bucket reaches the fire-room floor. It will also be fitted with an approved brake to control the drum. The ash-hoist will be fitted with the necessary sheaves, whip, and all appliances necessary for handling ash-buckets.

140. FIRE-ROOM BLOWERS.

There will be three blowers of approved pattern in each main fire-room, and one in each auxiliary fire-room.

These blowers must be capable of supplying to the fires continuously, with ease, sufficient air to maintain the maximum rate of combustion. They will take air from ducts, as shown on the drawings, and deliver into the fire-rooms. If necessary, light iron screens will be fitted in fire-rooms so that the air from the blowers will not blow the coal-dust.

Light iron bulkheads will be fitted as may be required by the Bureau of Steam Engineering so as to limit the space under air pressure.

The spindle-bearings must be accessible while the blowers are in motion, and will be of anti-friction metal fitted in composition boxes, and, together with their lubricating apparatus, must be thoroughly protected from dust.

If the blowers are fitted with casings, the casings must be so made that they can be removed without cutting out rivets.

141. VENTILATING FANS.

An exhausting fan with a capacity of at least 10,000 cubic feet of air per minute will be fitted in each engine-room. Air-ducts will be led to these fans with adjustable openings so arranged as to thoroughly ventilate the engine-rooms and shaft-alleys; the air to be discharged through ducts leading up the engine-room hatch with outlets so arranged that the foul air will not be drawn back down the hatch.

Each fan will be driven by an independent engine of the same kind as specified under blower-engine.

142. BLOWER-ENGINES.

Each blower will be driven direct by a balanced engine of two or more cylinders of an approved design, and of sufficient power to run the blower at full speed with steam of 100 pounds boiler pressure. The engine-valves must be of the slide or piston type.

All working parts must be closed in, but easily accessible for overhauling. The lubrication must be automatic and thorough, and such that the oil cannot come in contact with dust in the fire-room. The throttle-valve in the steam-pipe of each blowing-engine will be arranged to be worked from the fire-room floor, with suitable index to show how much it may be open. The steam-pipe for each blower will connect with auxiliary steam-pipe.

The shafts of blower-engines will be so fitted that a portable revolution-indicator can be quickly and easily applied without removing any part of the mechanism.

143. AIR-PRESSURE GAUGES.

A gauge of a pattern approved by the Bureau of Steam Engineering will be fitted in each fire-room to show the air pressure.

A portable gauge will also be supplied to each fire-room, with conveniences for connecting it to the furnaces, uptakes, and wherever it is desired to measure the air pressure.

All these gauges will indicate pressures in "inches of water."

144. AIR-LOCKS.

Suitable air-locks must be provided in the passages into the fire-rooms and in the ash-hoist ventilators to prevent the escape of air while the fire-rooms are under pressure.

145. FIRE-TOOL RACKS.

Racks will be fitted in each fire-room in convenient places for holding all necessary fire-tools.

146. ASH-DUMPS.

From each ash-hoist, on the upper deck, permanent over-head rails, suitably supported, will lead to the nearest ash-chute on each side of the ship, if directed. Each of these will be fitted with a traveler of approved design, with all necessary appliances for carrying the ash-buckets. At the top of each ash-chute a dumping-hopper of approved design will be fitted, so arranged as to fold up out of the way when not in use. The ash-buckets are to be balanced dump-buckets, with all necessary gear complete. All the ash-hoisting and dumping gear will be such that the buckets will not have to be lifted by hand.

147. ASH-SPRINKLERS.

A valve for wetting down ashes will be fitted in each fire-room where directed, and will be fitted with all necessary hose, couplings, nozzles, and reels or racks.

148. STEAM TUBE-CLEANERS.

A steam tube-cleaner, of approved design, will be fitted in each fire-room. Steam will be taken from the auxiliary steam-pipe. Sufficient length of steam-hose will be provided to easily reach all the tubes.

149. HYDRAULIC PUMPING MACHINERY.

There will be a hydraulic pumping plant to furnish water for revolving the gun-tables or turrets, working the guns, etc. The plant will consist of at least two independent pumps of approved design. Other things being equal, the lightest pump which will do the work efficiently will be selected.

The combined capacity of the pumps will be about 900 gallons per minute—the working pressure in all cases being 600 pounds per square inch.

The water ends of the pumps will be entirely of composition or bronze.

All piston-rods, side-rods, cross-heads, valve-stems, links and levers of valve-motions, shafts and rock-shafts will be made of forged-steel. If supplemental pistons are used

for the purpose of moving the main valves, the latter will also have a positive motion, which will prevent the piston striking the cylinder-heads in case of the supplemental pistons not acting quickly. If duplex pumps are used, the valve-motion must be adjustable. If direct-acting pumps are used, they must be so adjusted that, when performing the duty above specified, each piston shall make a stroke of such length that the lineal clearance at each end shall not be more than ten per cent. of the stroke. Straightway stop-valves will be fitted for the purpose of shutting off either pump at steam and water ends in case of accident. An approved automatic pressure-regulator will be fitted; also an adjustable relief-valve. Before being put on board, the plant will be tested to prove that the requisite duty can be performed, and that the regulator will stop and start the pumps promptly, when required, without allowing the water-pressure to fall below 550 pounds pressure. The above specified duty is to be performed with 100 pounds steam-pressure at the pump-throttle. The pump-valves will be metallic and easily accessible. The steam piston-rods will have metallic packing of the same kind as specified for main engines.

The pumps must either have packed pistons or packed plungers; if the packing used is other than ordinary commercial packing, spare packing will be supplied. The pumps must be proved incapable of getting in any position where they will not be started promptly when steam is turned on. They must work without pounding whether performing light or heavy duty.

A wrought-iron water-tank will be fitted for the plant, where directed, and connected with the suction-side of the pumps and with the discharges from the hydraulic engines.

The tank will have a capacity of 175 gallons.

This tank will have a drain-valve with pipe leading to the bilge. It will have a neat brass label, plainly inscribed "Fresh water only will be used in this tank." Connections will be made to it from the nearest auxiliary feed-pump for the purpose of filling it with fresh water.

It will have a closed top, bolted on, and will be fitted with a well-protected glass gauge and a vent-pipe.

The hydraulic pumps will be set in water-tight beds with drains leading to the bilge. The drains of the steam-cylinders will be piped to the top of the fresh-water tank; also having cocks by which the cylinders can be kept drained when not in use.

All parts of the hydraulic system, except the suction, will be tested to 1,200 pounds water-pressure.

150. HYDRAULIC PIPING.

All hydraulic pipe, except where otherwise directed, will be lap-welded iron or steel, screwed into wrought-iron or cast-steel flanges, which will be turned male and female so that the packing cannot be squeezed out.

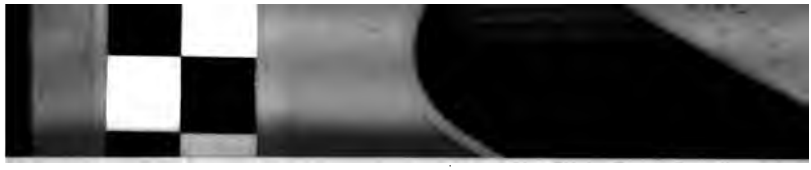
All joints will be made with leather or approved equivalent material. The sizes of pipes will be sufficient to allow the pumps to perform the prescribed duty when fitted on board and doing their regular work.

All pipes will be tested when in place to 1,200 pounds pressure per square inch. All stop-valves will be straight-way, of composition. All valves for admitting water to and exhausting from the turning-engines, and other hydraulic gear herein specified, will be balanced-valves, made perfectly tight by renewable packing, and working as easily as any that can be procured. Air-cocks will be fitted at the highest parts of any loops that may be made in the pipes.

A composition chamber will be fitted so as to revolve with the gun-table or turret, the pressure and exhaust-pipes leading into it in such a manner that they will not interfere with the guns when depressed.

This chamber will revolve around a double composition pipe leading into its bottom, and will have cup-leather packing, which will divide it into pressure and exhaust-passages. The chamber and pipes must be tight in all their parts and connections, when working with the working-pressure as well as under the test-pressure.

This chamber will have pressure and exhaust-nozzles of proper size for the pipes on the turning-engines, and for connections with such pipes as may be required by the Bureau of Ordnance, in leading to the valves con-



trolling the running in and out, the elevating and depressing, the loading of guns, and the working of the ammunition-hoists.

There will also be nozzles, if directed, for the connection of pipes for washing out the guns.

151. GUN-TABLE OR TURRET TURNING-GEAR.

There will be two gears for revolving each gun-table or turret. Each gear will consist of a multi-cylinder hydraulic engine secured to the gun-table or turret, transmitting its power through a pinion or through gears, the motion of the gun-table or turret being derived from a fixed rack under it.

The engines will be of approved type—collectively of sufficient power to turn the gun-table or turret at the rate of one revolution per minute with the guns run out and the vessel heeled 10 degrees.

The turning-engines must have all their parts easily accessible, and plans showing the engines in proposed position must be submitted to the Bureau of Steam Engineering before work is begun on them. The engines will not be placed under the guns.

On top of the rack will be placed a copper trough, which will be used as an oil receptacle for oiling the rack; it will receive its supply through pipes leading through the gun-table or floor of turret near the turning-engines, and will supply the oil to the rack through small openings in the bottom of the trough at the spaces between the teeth.

The turning-engines will be fitted in water-tight beds, with drain-pipes leading to a trough of copper to be placed underneath the rack so as to catch the drippings from the rack.

The rack will be made to comply with plans from the Bureau of Construction.

The turning-engines will have stop-valves in their pressure and exhaust-pipes, so that either engine can be shut off in case of accident. The cylinders will have ample drain-cocks.

The engines will be started, stopped, and reversed by a valve which will change the pressure and exhaust-ports.

There will be a hand-lever at each sighting station for controlling the moving of the gun-table or turret. This lever will move the valve of a supplemental hydraulic cylinder through a floating-lever so that the piston will follow the motion of the hand-lever. The piston of this cylinder will work, through a system of levers, the reversing-valve of the turning-engines. The connection to the reversing-valve will be by means of a floating-lever, one end worked by the gear within the barbette, and the other end so guided that when the gun-table revolves to its prescribed limit the reversing-valve will be automatically closed. The gear will also be so made that, in case of any leakage of the valves, allowing the gun-table to run beyond the prescribed limits, the engines will be reversed. The hand-levers in the barbette or turret will be fitted with locomotive latches and quadrants. Relief-valves will be so fitted that, when the water is shut off the turning-engines, or the engines reversed, the momentum of the gun-table or turret may be gradually overcome by the action of the valves. These valves will be adjustable as to the pressure of opening.

All cylinders, plungers, valve-boxes, and other parts in contact with water will be made of composition, gearing of cast-steel and composition, and other working parts of forged-steel. All toothed gearing will be cut. All working parts will be finished all over.

If the locking-bolt should be worked by machinery instead of by hand, as now required, the Bureau of Steam Engineering will furnish the necessary specifications.

152. WORKSHOP MACHINERY.

There will be fitted in the engineer's workshop the following tools, fitted to work by hand and power, to be of the best make and to be approved by the Bureau of Steam Engineering:

A double-geared engine-lathe. It will be of at least 12 inches swing and 34 inches between centers. It will be fitted with gears for cutting threads from 4 to 40 to the inch, and with four-grade cone-pulleys.

A shaping-machine, of at least 10 inches stroke and 8 inches traverse, with vertical adjustment to table, with three-grade cone-pulleys, and with chuck. It will have all the usual adjustments of first-class machines of its size.

A double-geared drilling-machine, with three-grade cone-pulleys, capable of drilling 1½-inch holes, with adjustable swinging-table and of at least 18 inches swing.

The tools above specified will be fitted where directed in the engineer's workshop. Each machine will be driven from a counter-shaft with cone-pulleys to suit the machine.

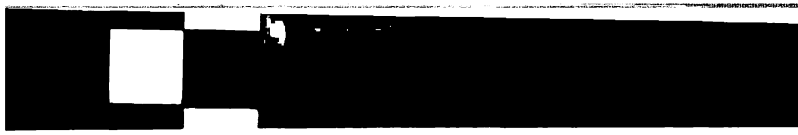
An engine of approved design will be provided to drive this machinery.

153. DISTILLING APPARATUS.

The distilling apparatus, placed where directed, will consist of two evaporators and two distillers, with their accessories, having a combined capacity of 10,000 gallons of potable water per 24 hours at a temperature of not more than 90° F. when the cooling water is taken in at a temperature of 60° F.

The evaporators will be made with shells of plate-steel with welded seams. The heads and flanges will be of cast-iron and the coils of copper, tinned inside and out. They will be felted and lagged, and will each be fitted with a safety-valve, steam-gauge, glass water-gauge, gauge-cocks, salinometer-pot, and blow-valve. They will take steam from the auxiliary steam-pipe, and the high and intermediate-pressure receivers, and will be fitted with automatic traps and with drain-pipes leading to the feed-tanks. The shells of the evaporators will be tested to 50 pounds to the square inch, and the coils and all parts subject to the boiler pressure to 230 pounds per square inch.

The distillers will be made with shells of sheet-brass, flanges and heads of composition, and coils of copper or brass, thoroughly tinned on both sides. The coils of each distiller will be divided into at least three parts, each with a separate inlet and outlet-valve.



A filter of approved design will be fitted to each distiller.

There will be efficient means for aerating the steam used in making distilled water.

There will be a steam-pump of approved pattern, and of a capacity of about 10 gallons per minute at ordinary speed, fitted to draw water from the filters and deliver it into the fresh-water tanks. The cylinders of the pump will be of "light service" proportions, for using steam of 60 pounds pressure. The water end of the pump will contain no copper or lead. A pipe will lead from the atmosphere, above the ship's awnings, to the suction of the pump, with a regulating-valve, so that air can be forced into the tanks with the water. In the water-suction of the pump will be fitted an approved water-meter, made without copper or lead. The discharge-pipes to the fresh-water tanks will lead to the bottoms of the tanks, so that air forced in will rise through the water.

A pump of approved pattern and size will be fitted for feeding the evaporators; also one to circulate the cooling water through the distillers to draw water from a special sea-valve placed where directed. Also a pump, with metal valves, which can draw the condensed water from the evaporators and deliver it into the auxiliary feed-pipe. This pump will be placed below the level of the evaporators and will take the condensed water from the traps.

The condensing water after leaving the distillers will be led forward by a pipe of approved size, with connections for flushing the crew's water-closets, with branches to the officers' water-closets. This pipe must be placed so that water will flow to all the closets at the same time. A by-pass pipe will be provided so that water may pass to the closets when the distillers may be shut off.

The evaporators and distillers will be so fitted that their coils can be easily removed for repairs. There must be no internal detachable joints in the coils of either evaporators or distillers.

In connection with the distilling apparatus there shall be provided an approved refrigerating plant, of a capacity

equal to a one-ton ice machine. There will also be a connection of the same size as the pipe connecting the evaporator and distiller from the evaporators to the main and auxiliary condensers.

154. WASH-WATER TANKS, ETC.

There will be one or more cylindrical wrought-iron tanks, of a combined capacity of 400 gallons, to hold fresh water for firemen's use. They will be fitted in such places as may be designated. Each tank will have an overflow-pipe, without valve or cock, leading to the bilge, with the end in plain view from the fire-room; also a drain-pipe with its valve easily reached from the fire-room. A pipe will be led direct from the fresh-water outlet of the distiller for filling these tanks without passing the water through the filter; this pipe to have a locked cock.

There will be an approved hand-pump connected as follows: to have suction-pipes from the feed-tank suction-pipe and from the tanks above mentioned, and to discharge into these tanks and into the tank in the firemen's wash-room; all pipes fitted with stop-valves close to pump. The pump will have a dead-weight relief-valve set at just sufficient pressure to allow the wash-room tank to be filled.

A cylindrical copper tank, of about 50 gallons capacity, will be fitted in the firemen's wash-room and connected with the pump above specified. The tank will be supplied with a vent-pipe with a float-valve, which will close the vent when the tank is full. There will be a service-pipe from the tank, with a branch to each wash-basin, and one for filling buckets. Each of these branches will have a self-closing lever-faucet. In the service-pipe, close to the tank, will be a locked cock.

155. MAIN STEAM-PIPES.

A pipe of approved size will connect the stop-valves of the boilers in the forward fire-room, and a similar pipe will connect the stop-valves of the boilers in the after

fire-room. The pipes will be led as shown, and have stop-valves where shown.

Straightway-valves will be used where shown.

It must be possible to regulate the stop-valves next to the after bulkhead of after fire-room from the engine-rooms.

156. AUXILIARY STEAM-PIPES.

There will be an auxiliary steam-pipe extending through engine and boiler compartments and to the auxiliary boilers, and to the windlass, steering, dynamo, and ventilating-fan engines, and to the engineer's workshop. It will connect with the auxiliary stop-valves in both boiler compartments and with the main steam-pipe in each engine-room abaft the separator. There will be a stop-valve in the after part of each fire-room close to the bulkhead, one in each engine-room close to the bulkhead, and one in each connection with the main steam-pipe. Branches will extend to all auxiliary machinery herein specified. The pipe will be of sufficient size to supply all auxiliary machinery, including dynamos and ventilating-fans, when taking steam from abaft the separators. The auxiliary steam-pipe will be arranged, where possible, so that steam condensing in it may drain back to the separator. Where it is not possible to so arrange it, or wherever pockets necessarily occur, the pipe will be drained and trapped. All branches from the pipe to pumps or engines on a lower level will have the stop-valve for such machinery close to the main pipe, with a spindle for working it from below, so that when the pump or engine is standing idle there will be no opportunity for water to collect in the vertical pipe leading to it, which must be blown out before starting.

A separate auxiliary steam-pipe will be fitted, connecting the dynamo-engines with the boilers; there will be a stop-valve on each boiler and the pipes will lead as direct as possible to a separator placed near the dynamo-engines; all dips and pockets to be carefully avoided. Valves will be fitted so that the branch leading to any

The dynamo-engine exhaust-pipes must be so led and joined by an approved Y or T that one engine cannot exhaust against another, or the unused engine be flooded, and swing-check valves will be fitted in all exhaust-pipes close to the valve-chests.

158. BLEEDER-PIPES.

A 5½-inch branch from the main steam-pipe in each engine-room will lead to each main condenser, with a stop-valve operated from the working-platform.

159. INTERMEDIATE AND LOW-PRESSURE STEAM-PIPES.

A 4½-inch branch from the main steam-pipe will lead to each intermediate, and a similar pipe to each low-pressure valve-chest, each with a stop-valve.

160. SEPARATORS.

There will be in each main steam-pipe in each engine-room a centrifugal or other approved separator. They will be made entirely of cast-steel and plate-steel, each fitted with a well-protected glass gauge of the automatic-closing pattern, and an approved automatic steam-trap, with drain delivering into feed-tank. There will also be a drain connected directly to the separator, discharging overboard or into the main feed-pump suction at will.

161. MAIN FEED-PUMP EXHAUST.

The exhaust-pipes from the main feed-pumps, in addition to the connection with the exhaust-main, will be so arranged that the exhaust-steam can be turned into the feed-pump suction instead of into the auxiliary exhaust-pipe—chambers with suitable nozzles for this purpose being fitted in the suction-pipes.

162. ESCAPE-PIPE.

There will be a 12-inch copper escape-pipe abaft each smoke-pipe, extending to its top, finished and secured in an approved manner. This pipe will have branches leading to all the safety-valves in its compartment and to the safety-valves on the auxiliary boilers. The auxiliary exhaust-pipe will also lead into the escape-pipes.

163. MAIN FEED-PIPES.

A seamless-drawn brass pipe of the same diameter as the discharge from the auxiliary feed-pumps in the engine-rooms will extend from each engine-room to the fire-rooms; it will be placed above the floor-plates. A branch will lead from this pipe to each of the main check-valves on the boilers.

There will be a straightway-valve in each branch pipe close to the main fore-and-aft feed-pipe, and a straightway-valve in the main fore-and-aft feed-pipe where it passes through each water-tight bulkhead.

A seamless-drawn brass pipe will connect each main feed-pump in the fire-rooms with the branch pipe leading from the main fore-and-aft feed-pipe to the boiler main check-valves in the same fire-room, and branch pipes with straightway-valves will lead to the main check-valves on the auxiliary boilers. This pipe will be of the same diameter as the branch pipes, and will be fitted with a screw check-valve at the pump, and connect with the branch pipe between the straightway-valve in that pipe and the main check-valve on the boiler.

There will be an athwartship-pipe in the engine-rooms connecting the fore-and-aft main feed-pipes with a valve where the pipe passes through the fore-and-aft bulkhead.

164. AUXILIARY FEED-PIPES.

A seamless-drawn brass pipe of the same diameter as the discharge from the auxiliary feed-pumps in the engine-rooms will extend from each engine-room to the fire-rooms. It will be placed above the floor-plates, and will be connected with the main fore-and-aft feed-pipes in the engine-room by a straightway-valve. A branch will lead from this pipe to each of the auxiliary check-valves on the boilers.

There will be a straightway-valve in each branch pipe close to the auxiliary fore-and-aft feed-pipe, and a straightway-valve in the auxiliary fore-and-aft feed-pipe where it passes through each water-tight bulkhead.

A seamless-drawn brass pipe will connect each auxiliary feed-pump in the fire-rooms with the branch pipe

leading from each auxiliary fore-and-aft feed-pipe to the boiler auxiliary check-valves in the same fire-room, and branch pipes with straightway-valves will lead to the auxiliary check-valves on the auxiliary boilers.

This pipe will be of the same diameter as the branch pipes, and be fitted with a screw check-valve at the pump, and connect with the branch pipe between the straightway-valve in that pipe and the auxiliary check-valve on the boiler.

165. FEED-WATER HEATER.

There will be for each fire-room a feed-water heater of suitable size, placed where directed. Plans showing the type and arrangement of heater must be submitted to the Bureau of Steam Engineering for approval before work is commenced on them.

166. GREASE EXTRACTOR.

Approved grease extractors, subject to the approval of the Bureau of Steam Engineering, will be fitted either in the exhaust-pipes leading to the condensers or in the feed-pipes.

167. FIRE-MAIN.

A pipe will extend fore and aft on the berth-deck, with an approved fire-plug of Navy standard size, placed where directed in each compartment. This pipe will be connected with the discharges of the engine-room fire-pumps, the engine-room auxiliary pumps, and the auxiliary feed-pumps in the fire-rooms. Two branches from this main will lead up to the superstructure and be fitted with fire-plugs. A branch from the main will lead to each magazine passing-room, one to the compartment abaft the engines, and one to each compartment forward. Each of these branches will be fitted with a fire-plug, and will be so connected that all of the fire-pumps can work on it. There will be a fire-plug in an approved position in each engine-room and each fire-room. All fire-plugs will be fitted with straightway-valves. Drain-pipes will be fitted to drain all parts of the fire-main and branches.

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A reverse coupling will be supplied, with adapters to suit the various sizes and threads of fire-hose commonly in use, for the purpose of filling the boilers with fresh water from hose on shore, or on boats alongside.

There will be a 1½-inch pipe leading from the auxiliary steam-pipe to each coal-bunker and hold, to be used for extinguishing fire. This pipe will have a valve in it close to auxiliary steam-pipe, and another at each coal-bunker or hold bulkhead.

168. PIPES THROUGH WATER-TIGHT BULKHEADS AND DECKS.

They will be made water-tight by stuffing-boxes, flanges, or other approved means.

Pipes must not be led in such manner that the angles or tees of bulkheads have to be cut. Holes through wooden decks, where pipes pass through, will have brass or copper thimbles, made water-tight, extending at least three inches above decks.

169. PIPES THROUGH COAL-BUNKERS.

They will be protected by iron casings, made in sections, easily removable for repairs. Pipes must not be led under openings of coal-chutes.

170. DRAIN-PIPES AND TRAPS.

All places where condensed steam can accumulate will be provided with drain-pipes and cocks or valves of ample size, and with approved automatic traps, which will discharge into feed-tanks or condensers, or as directed. All traps will have by-pass pipes and valves for convenience of overhauling. The lowest parts of all water-pipes and all pump-cylinders and channel-ways will have drain-cocks with pipes, where required. The handles of all drain-cocks will point downward when closed. All glass water-gauges under pressure will be fitted with valves of approved automatic-closing pattern.

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171. THICKNESS OF PIPES.

The thickness of metal in the principal pipes will be as follows, by B. W. G.:

Steam-pipes above 12 inches bore	No. 3
Steam-pipes above 9 inches bore and less than 12 inches bore	No. 4
Steam-pipes above 7½ inches bore and less than 9 inches bore	No. 5
Steam-pipes above 5 inches bore and less than 7½ inches bore	No. 6
Steam-pipes above 4 inches bore and less than 5 inches bore	No. 9
Steam-pipes of and above 3 inches bore and less than 4 inches bore	No. 11
H. P. exhaust to I. P. cylinder	No. 4
I. P. exhaust to L. P. cylinder	No. 5
L. P. exhaust to condenser	No. 7
Circulating-pump suction and discharge-pipes	No. 7
Bilge-injection pipes	No. 11
Air-pump discharge to feed-tanks	No. 12
Feed-pump suction-pipes	No. 13
Feed-pipes	No. 4
Blow-pipes	No. 9
Auxiliary exhaust-pipes	No. 13
Escape-pipes	No. 13
Dry-pipes	No. 14
Connections to fire-main	No. 10
Galvanized wrought-iron bilge-suction pipes	No. 7

All bends in brazed-copper pipes will be one gauge thicker than straight parts.

All pipes of which the thickness is not given in the above list will be made of approved thickness.

172. MATERIAL AND FITTING OF PIPES.

All pipes, except the lower ends of bilge-suction pipes, will be of copper, unless otherwise specified.

The lower parts of bilge-suction pipes will be of galvanized iron.

All feed and blow-pipes, all bilge-suction pipes except the lower parts, and all steam-pipes less than 3 inches in diameter, will be seamless-drawn. All copper pipes not seamless-drawn will be brazed. All copper pipes over 3 inches in diameter will have composition flanges riveted on and brazed, and will have the end of the pipe expanded into a recess in the face of the flange; all under 3 inches will have flanges or approved composition couplings brazed on, and the end of the pipe will be expanded into a recess in the face of the flange. All feed and blow-pipes will have composition flanges. All flanges will be faced and grooved, and joints made with approved material. All composition flanges below the floor-plates will be connected by bolts and nuts of rolled manganese or Tobin bronze. All copper-pipe T-pieces and fittings will be of composition, except where otherwise directed. Expansion-joints of approved pattern will be fitted where required. Slip-joints, if fitted, will have stop-bolts and flanges. All copper pipes in bilges will be well painted and covered with water-proof canvas, and must not rest in contact with any of the iron or steel work of the vessel.

All steam, air, and water pipes of refrigerating-machines will be of copper with flange-joints; all other pipes will be fitted with flange-joints, to be approved by the Bureau of Steam Engineering.

173. AUXILIARY ENGINE STOP-VALVES.

Each auxiliary engine will have stop-valves in both steam and exhaust-pipes as close to cylinders as possible. Exhaust stop-valves will be straightway where practicable. All pumps, except circulating-pumps, will have screw check-valves in both suction and delivery-pipes close to pump-cylinders, so arranged that they may be kept off their seats when desired.

174. PUMP-CYLINDERS.

All pump-cylinders, together with their valve-boxes and fittings, will be made of composition, unless otherwise specified. Air-chambers will be fitted on the delivery sides of pumps or in the pipes, as may be directed.

The water-cylinders of all vertical pumps will be so arranged that the pistons are easily accessible and fitted for overhauling without disturbing the framing or piping. All pumps will have either packed pistons or packed plungers, excepting air-pumps, which will be made as shown.

175. PUMP-RELIEF-VALVES.

All feed and fire-pumps will have adjustable spring-relief valves of approved design, connecting the delivery and suction passages.

176. SEA-VALVES.

There will be in the various compartments sea-valves, as follows:

In each engine compartment a screw stop-valve, having independent connection to the side of the vessel, of sufficient size to supply water to the fire, bilge, and the auxiliary pumps in that compartment, also with a 4½-inch nozzle for connection of the water-service pipes. Also in each engine compartment a double valve-box with a screw non-return valve for the discharge from the fire and bilge and auxiliary pumps, and a non-return valve for trap discharge. This valve-box may, if desired, be connected to the outboard nozzle of the main outboard-delivery valve. The main injection and outboard-delivery valves will be as elsewhere specified.

In each main boiler compartment there will be a Kingston valve for a bottom-blow and pump-discharge, and a sea-valve for each auxiliary pump sea-suction.

There will also be a sea-suction valve for the distiller circulating-pump, placed where directed.

177. BILGE-STRAINERS.

Each pipe leading from the bilges or from the drainage system of the vessel to the pumps will be fitted with a Macomb, or equivalent, strainer, above the floors.

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The baskets of Macomb strainers will have a diameter equal to one and one-half times the diameter of the pipe and a length equal to twice the diameter of the pipe.

178. ATTACHMENT OF VALVES TO HULL.

Steel strengthening-rings will be riveted to plating of hull around the openings for all sea-valves. The valve-flanges will be bolted to these rings by rolled manganese or Tobin bronze studs, care being taken not to drill the holes entirely through the rings. A zinc protecting-ring will be fitted in each opening in outer skin in such a manner as to be easily renewed.

All suction-valves will have strainers over their openings on the outside of the vessel. These strainers will have $\frac{5}{8}$-inch holes with a collective area equal to twice the area of the valve-openings. Strainers must be fastened to valve-casings and not to the plates of the hull. All valves below the turn of the bilge will have pipes secured to the outer skin of hull and passing through stuffing-boxes in the inner skin.

179. COCKS AND VALVES.

All cocks and valves and their fittings, except as otherwise specified, will be of composition. All hand-wheels will be of finished brass, except as otherwise specified, and will be at least one and one-half times as great in diameter as their valves. All cocks communicating with vacuum spaces will have bottoms of shell cast in and have packed plugs. All cocks over 1 inch in diameter will have packed plugs.

Valves of approved pattern will be supplied wherever necessary to complete the various pipe systems, whether herein specified or not. All valves will be so fitted as to be easily ground in, and be fitted where required with grinding-in guides and handles. No conical-faced valve will have a bearing on its seat of more than $\frac{3}{16}$ inch in width. All valve-spindles must turn right-handed to close, and have outside threads where practicable. Cocks and valves may have, where approved, in lieu of wheels

or permanent handles, removable box or socket-wrenches, marked and stowed in convenient racks—these handles to be so fitted that they can only be removed when the valves are closed. All cocks and valves underneath the floor-plates will have their wheels or handles above the floor-plates, in easily accessible positions, unless otherwise directed. The sizes of valves as given in these specifications refer to the diameter of the equivalent clear openings.

180. LABELS ON GEAR AND INSTRUMENTS.

All cocks will have engraved brass plates to show their uses and to indicate whether open or shut. All valves except such as may be otherwise directed will have similarly engraved plates to show their uses, or have the same plainly engraved on hand-wheels.

All hand-levers or their quadrants will be similarly marked. Gear for working valves from deck will be marked as elsewhere specified.

All main steam stop-valves will have indices to show to what extent they are opened.

All gauges, thermometers, counters, telegraph-dials, speaking-tube annunciators, and revolution-indicators will be suitably engraved to show to what they are connected.

All engraving will be deep and be filled in with black cement.

181. CLOTHING AND LAGGING.

The main cylinders and valve-chests, after being finally secured in place in the vessel and tested, will be covered with approved incombustible non-conducting material and neatly lagged with black walnut all over, with polished brass bands and round-headed brass screws. The lagging will be made in removable sections over each cylinder, valve-chest, and man-hole cover, the sections to be of such size as to be easily handled, and all parts plainly marked. The lagging elsewhere will be so secured

All parts of the condensers except the water-chests at ends will be clothed with approved material, put on in sections so as to be easily removed and replaced.

All steam and exhaust-pipes, the separators, the feed-water heaters, and all steam-valves will be clothed in an approved manner with a satisfactory non-conducting material, covered with canvas, well painted. The main steam and exhaust-pipes in engine-room and the main separators will be also covered with black-walnut lagging with brass bands. The canvas covering of steam-pipes will be secured to bulkheads where the pipes pass through them.

The steam-cylinders of all auxiliary engines will be clothed and lagged the same as main cylinders.

After the boilers are in place and have been tested and painted they will be covered all over, except where directed, as low as the saddles, with approved incombustible non-conducting material at least 1¼ inches thick. This clothing will be covered on tops, sides, and back heads and on fronts, where required, by galvanized wrought-iron plates about No. 18 B. W. G., flanged not less than 1 inch and bolted together; also secured to boiler-plates at bottom by angle-iron, which will be held in place by ½-inch bolts tapped part way into the boiler-plates, and held off from the boiler-plates elsewhere by suitable distance-pieces.

182. RADIATORS.

Radiators of approved patterns, with such areas as may be called for in the specifications for radiators to be furnished by the Bureau of Steam Engineering, will be furnished, fitted, and connected.

Each radiator or coil of more than 10 square feet will be divided into two parts. All radiators will be fitted with approved valves, with valve-stem guards, and removable keys for valve-stems. The ends of the stems will be triangular in cross-section.

The radiators in the wardroom, cabin, and steerage will consist of pipes led along the deck at the bottom of the bulkheads, and will be covered with an approved metallic casing easily removable.

The steam and drain-pipes will be of seamless-drawn brass, of iron-pipe size, suitably connected by composition fittings in a manner that will permit them to be easily taken down for repairs.

All union-joints will be coned or have corrugated copper washers.

All holes through decks and bulkheads will be thimbled with brass.

Steam and drain-pipes will be clothed where near wood-work, and elsewhere as required.

The steam-pipes will connect with the auxiliary steam-pipes where directed, and be fitted with adjustable reducing-valves.

The drain-pipe of each circuit will have an approved automatic steam-trap discharging into feed-tank, and elsewhere as directed.

Independent steam-pipes will lead from engine and fire-rooms to the principal divisions of the officers' quarters and forward parts of the ship.

183. WHISTLES.

An approved polished brass chime steam-whistle, with a bell of about 8 inches diameter, will be placed forward of the forward smoke-pipe, well above the level of the awnings, and connected to the auxiliary steam-pipe by a pipe having a stop-valve at its lower end and a working-valve at the upper end. The pipe will have an expansion-joint at lower end. There will be a shrieking whistle of approved pattern and size, placed where directed, and connected similarly to the whistle. Both whistle connections will have drain-pipes fitted at the lowest points.

184. HOSE AND HOSE-REELS.

A sufficient length of hose will be supplied for each engine-room and each fire-room, to lead to the farthest part of the adjoining coal-bunkers below the armored-deck. The hose for engine-rooms will be of the best quality rubber-lined linen, and that for fire-rooms will be the best quality four-ply rubber engine-hose—all 2½ inches diameter, with standard couplings. Each hose

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will be supplied with a rubber hose-pipe with handles. A pair of spanners will be supplied for each hose-nozzle.

A hose-reel of approved pattern will be fitted in each fire-room, and a swinging bracket or similar hose receptacle in each engine-room. Hose-pipes and spanners will be fitted in beckets.

185. SHAFTS THROUGH BULKHEADS.

All shafts passing through water-tight bulkheads will be fitted with stuffing-boxes, each in two parts.

186. FLOORS AND PLATFORMS.

The engine-rooms and fire-rooms will be floored with wrought-iron plates ¼ inch thick, with neatly matched flat-topped corrugations. The plates will be of convenient size and easily removable. They will rest on proper ledges of angle or T-iron, and will have drain-holes where necessary. Platforms will be provided for getting at all parts of the main and auxiliary engines and boilers. These platforms, where placed over moving machinery, will be fitted the same as the lower floors. In other places they will be made of iron rods ⅝ inch square, placed ¾ inch apart.

187. LADDERS.

Ladders will be fitted wherever necessary for reaching the engine-rooms and fire-rooms from deck, and for reaching the various platforms, passages, and parts of machinery. The engine-room ladders will be made with plate-iron sides and light cast-iron treads with corrugated tops. The fire-room ladders will be made with plate sides and double square bar-treads.

All ladders will be so fitted as to be easily removable where required, and will be jointed and hinged, with necessary fastenings and gear, where they have to be moved when closing hatches. Light iron ladders will be fitted to and through one ventilator in each engine-room as means of egress when the battle-hatches are closed.

Gear will be provided for quickly opening the battle-hatches over the fire-room ladders, this gear to be worked from fire-rooms.

188. HAND-RAILS.

Hand-rails, easily removable where required, will be fitted to all ladders and platforms, around moving parts of machinery, and along bulkheads and passage-ways. The hand-rails and stanchions will be made of deoxidized bronze, or of approved equivalent metal which will not easily tarnish, and will be polished all over. The lower ends of stanchions will pass through floor-plates with nuts underneath.

189. GEAR FOR WORKING VALVES FROM DECK.

The safety-valves, boiler stop-valves, and engine-room stop-valves, as elsewhere specified, will have suitable gear for working them from the main deck.

The rods of the gear will be guided and supported on deck by cast composition standards, left rough and painted. Each rod will have a hand-wheel at least 3 feet above the deck. The stop-valve hand-wheels will be 12 inches in diameter, each to be fitted with an approved lock and key; all locks and keys to be alike. The wheels will be of brass, polished, and will have their rims connected with the hubs by plain discs without holes in them. Or in lieu of hand-wheels, if directed, polished brass bar-handles will be fitted to squares on the turning-rods, and will be stowed in beckets on bulkheads. The tops of rods will be protected by brass caps. All hand-wheels will be engraved with name, or cast-brass label-plates with polished raised letters will be fixed to adjoining bulkheads.

190. LIFTING-GEAR.

Efficient lifting-gear, consisting of traveler-bars and pulleys, deck-beam clamps, turnbuckles, shackles, hooks, eye-bolts, and as may be directed, will be fitted wherever required for lifting parts of the machinery for overhauling and repairing.

Holes will be tapped in all the principal movable parts of machinery for this purpose.

191. OIL-TANKS.

Oil-tanks, of 1,500 gallons total capacity, divided as directed, will be fitted where directed, with facilities for filling from deck. They will be made of galvanized wrought-iron not less than ⅛ inch thick, and will each have a glass gauge, a man-hole and cover near the top, and a locked-cock for drawing oil. In each engine-room there will be fitted two copper oil-tanks of 20 gallons each and two of 8 gallons each, and in each boiler compartment one of 5 gallons, all with lock-cocks. All oil-tanks will be fitted with drip-pans.

Each of the larger oil-tanks will have a hand-pump and pipes for filling the smaller tanks.

Two galvanized-iron tallow-tanks, with hinged covers, will be fitted where directed.

192. VENTILAOTRS.

Ventilators, with cowls well above the awnings, will be fitted as may be required.

The ventilators will be of wrought-iron, No. 11 B. W. G., butted and single-strapped and flush-riveted. The cowls will be movable, of No. 12 B. W. G. copper, not planished and at least 48 inches in greatest diameter. The base, rings of cowls will be of composition, finished on working parts but left unfinished on the outside. All cowls will be fitted with gear for turning them from the engine and fire-rooms, the gear to be of composition except the spindles, which will be of wrought-iron. Brass hand-wheels or T-handles will be fitted to spindles in engine and fire-rooms.

There will be at least one ventilator in each fire-room, fitted with all appliances for hoisting ashes. Fire-room ventilators will be provided with air-tight doors to prevent escape of air when the fire-rooms are under pressure.

193. TOOLS.

The following tools will be furnished in addition to those elsewhere specified:

One set of wrenches complete for each engine and each fire-room, to be fitted for all nuts in their respective compartments, plainly marked with sizes, and fitted in iron racks of approved pattern. The wrenches for nuts of bolts less than one inch in diameter will be finished, and for all over two inches in diameter will be box-wrenches, where such can be used. Socket-wrenches will be furnished where required. Open-end wrenches will be of steel or wrought-iron, with case-hardened jaws, all others of wrought-iron or cast-steel;

One pair of taps, on rod, for tapping front and back tube-sheets of main boilers at one operation. This will be a duplicate of that used in originally tapping the sheets, and be so packed as to be perfectly protected from injury;

A fixed trammel for setting the main valves without removing the covers, the valve-stems to be properly marked for this purpose;

Fixed trammels or gauges for aligning crank-shafts, brass pins being let into pillow-blocks and center-marked for this purpose;

Two complete sets of fire-tools for each fire-room;

Six coal and six ash-buckets for each fire-room.

All trammels and gauges will have protecting cases. All tools will be conveniently stowed.

194. DUPLICATE PIECES.

The following duplicate pieces, in addition to others specified, will be furnished, fitted, and ready for use, viz:

One set of valves for each pump;

One valve-seat, with guards and bolts complete, for air-pumps;

One-half set of follower-bolts and nuts for each steam-piston;

One-half set of springs for each steam-piston;

Four bottom brasses and four top brasses for crank-shaft bearings; two for forward and two for after engines;

Four crown-brasses and two butt-brasses for crank-pins; two for forward and two for after engines;

Four caps and four butt-brasses for cross-head journals; two for forward and two for after engines;

Four composition gibs complete for cross-heads;

A full set of blades for each propeller, fitted to propeller-bosses. These blades will be of such pattern as may be directed after the trial of the vessel;

One complete set of brasses for each main engine valve-gear;

One complete set of brasses for each circulating-pump engine, each air-pump engine, each main feed-pump, each fire-pump, and each blowing-engine;

Four spare cup-leathers for each one fitted in hydraulic gear;

One piston-rod for each piston of each pump;

One feed-check valve complete;

One bottom-blow valve complete;

One surface-blow valve complete;

One complete set of metallic packing for each stuffing-box;

A spare hose and nozzle for each steam tube-cleaner;

One-eighth of a complete set of grate-bars and bearers for all furnaces, and one pattern for each casting;

Four dead-plates for furnaces and one pattern for same;

Two ash-pit doors;

One hundred and fifty stay-tubes for main boilers and twenty-five for the auxiliary boilers, threaded to fit threads in tube-sheets, with ends wrapped in canvas;

Two hundred and fifty ordinary boiler-tubes for main boilers and fifty for the auxiliary boilers, swelled at one end and annealed, ready for use;

Two hundred main condenser-tubes, packed in boxes;

Twenty-five auxiliary condenser-tubes, packed in boxes;

One hundred condenser-tube glands;

One spare spring for each safety-valve and relief-valve;

One spare basket for each Macomb bilge-strainer;

One set of coils for each evaporator.

Wherever duplicate pieces are furnished for one of two or more pieces of machinery of the same size, they will be made strictly interchangeable.

All finished duplicate pieces not of brass, except as otherwise specified, will be painted with three coats of white lead and oil and well lashed in tarred canvas, with the name painted on outside. Brass pieces will be marked or stamped. All pieces will be stowed in an approved manner.

All boiler-tubes will be securely stowed in racks, or as directed.

195. MATERIALS AND WORKMANSHIP.

All castings must be sound and true to form, and before being painted must be well cleaned of sand and scale, and all fins and roughness removed.

No imperfect casting or unsound forging will be used if the defect affects the strength or to a marked degree its sightliness.

All nuts on rough castings will fit facings raised above the surface, except where otherwise directed. All flanges of castings will be faced, and those coupled together will have their edges made fair with each other. The faces of all circular flanges will be grooved.

All bolt-holes in permanently fixed parts will be reamed or drilled fair and true in place, and the bodies of bolts finished to fit them snugly.

All pipes beneath floor-plates will be connected by forged bolts and nuts of rolled manganese or Tobin bronze.

All brasses will fit loosely between collars of shafting.

All brasses or journals will be properly channeled for the distribution of oil.

Packing for stuffing-boxes will be such as may be approved.

All small pins of working parts will be well case-hardened.

All steel joint-pins of valve-gear will be hardened and ground to true cylindrical surfaces.

All materials used in the construction of the machinery will be of the best quality. The iron castings will be made of the best pig-iron, not scrap, except where otherwise directed.

Composition castings will be made of new materials. The various compositions will be by weight, as follows:

For all journal-boxes and guide-gibs where not otherwise specified—

Copper 6, tin 1, and zinc ¼ parts.

Naval brass—

Copper 62, tin 1, and zinc 37 per cent.

For composition not otherwise specified—

Copper 88, tin 10, and zinc 2 per cent.

Muntz metal will be of the best commercial quality.

Anti-friction metal will be of approved kind.

Ornamental brass fittings will be of good uniform color.

All castings will be increased in thickness around core-holes. Core-holes will be tapped and core-plugs screwed in and locked, except where bolted covers are used, or where it may be directed that the holes be left open.

All steel forgings will be without welds and free from laminations.

All flanges, collars, and off-sets will have well-rounded fillets.

All boiler-plates, stays, and tubes will be well cleaned of mill-scale by pickling or other approved means.

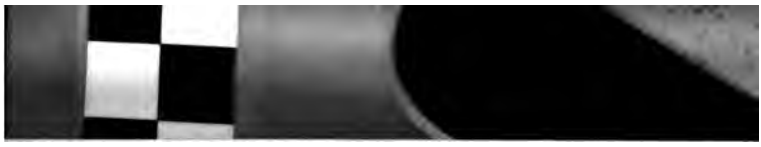
All flanged parts of boilers will be annealed, after flanging, in an approved manner.

India-rubber valves will be of approved kind, of best commercial quality.

All bolts for securing the boiler attachments will, where practicable, be screwed through the boiler-plates, with heads inside.

All work will be in every respect of the first quality and executed in a workmanlike and substantial manner.

Any portion of the work, whether partially or entirely completed, found defective, must be removed and satisfactorily replaced without extra charge.



196. TESTS OF MATERIAL.

All steel used in the construction of the boilers, and all steel forgings and castings, will be tested in accordance with rules prescribed by the Navy Department.

All boiler and condenser-tubes will be tested to 300 pounds pressure per square inch, applied internally before being put in place.

India-rubber valves, taken at random, must stand a dry-heat test of 270° F. for one hour, and a moist-heat test of 320° F. for three hours, without injury.

197. TESTS OF BOILERS AND MACHINERY.

Before the boilers are painted or placed in the vessel they will be tested under a pressure of 250 pounds to the square inch above atmospheric pressure. This pressure will be obtained by the application of heat to water within the boilers, the water filling the boilers quite full.

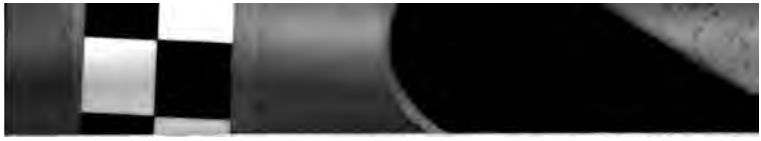
The steam-pipes and valves, the auxiliary engines, and all fittings and connections subjected to the boiler pressure will be tested by water pressure to 250 pounds to the square inch.

The high-pressure cylinders, jackets, and valve-chests will be tested by water pressure to 240 pounds to the square inch, the intermediate-pressure cylinders and connections to 150 pounds, and the low-pressure to 100 pounds. The exhaust side of the low-pressure valve-chests will be tested to 30 pounds. The condensers will be tested to 30 pounds.

The pumps, valve-boxes, and air-vessels of the feed, fire, and bilge-pumps will be tested to 300 pounds per square inch. The cylinders and condensers will be tested before being placed on board, and must be so placed that all parts may be accessible for examination by the Inspector during the tests. All parts will also be tested after being secured on board. No lagging or covering is to be on the cylinders or condensers during the tests.

198. PAINTING.

After a satisfactory test the boilers will be painted on the outside with two coats of brown zinc and oil, and when in place the fronts will be painted with one coat of black paint.



All engine-work, not finished, will be primed with two coats of brown zinc and oil, and when placed in position on board the vessel will be painted with two coats of paint of approved color. The shafting, when in place, will be painted with two coats of red lead and oil and two coats of black paint.

The smoke-pipes will be thoroughly painted before and after erection on board. The ventilators and cowls will be painted similarly to the smoke-pipes, except the interiors of the cowls, which will be painted vermilion.

All pipes will be painted in accordance with a schedule to be hereafter furnished.

199. PRELIMINARY TESTS AND TRIALS.

Steam will not be raised in the boilers until after the water-test on board, unless desired for drying or testing joints, for which purpose the pressure must not exceed 10 pounds per square inch.

After testing, steam will be raised in the boilers, whenever required, to test the connections and the workings of all parts of main and auxiliary engines. All expense of such preliminary tests will be borne by the contractor.

200. SUPERINTENDING ENGINEER'S OFFICE.

A suitable office and a suitable drafting-room, properly furnished and heated, will be furnished by the contractor for the use of the superintending naval engineer and his assistants.

201. RECORD OF WEIGHTS.

All finished machinery, boilers, and appurtenances thereof, as fitted, and all spare machinery and tools herein specified, will be weighed by the contractor in the presence of the superintending naval engineer or one of his assistants before being placed on board; and no part of the material will be placed on board without being so weighed to the satisfaction of the superintending naval engineer.

202. WORKING DRAWINGS.

All drawings necessary for the prosecution of the work must be prepared by and at the expense of the contractor.

Those which are developments of the drawings furnished and of these specifications will be subject to the approval of the Bureau of Steam Engineering before the material is ordered or the work commenced.

In the drawings furnished, figured dimensions, where given, will be followed, and not scale dimensions, unless otherwise directed. All discrepancies discovered in drawings, or between drawings and specifications, will be referred to the Bureau of Steam Engineering.

A copy of each working drawing will be furnished to the superintending naval engineer before the work shown by the drawing is commenced. A copy of each drawing accompanying orders for steel castings or forgings will also be supplied when the work is ordered.

203. DRAWINGS OF COMPLETED MACHINERY.

The contractor will make and furnish to the Bureau of Steam Engineering, through the superintending naval engineer, a complete set of drawings of the boilers, machinery, and appurtenances as actually completed, including plans of the same as fitted on board the vessel. These drawings will include every piece of machinery, both in whole and in part, and will be in such detail as would enable the entire machinery to be duplicated without additional drawings. No sheet will contain drawings of more than one part of the machinery, except those intimately connected with each other. The detail drawing of each part of machinery will be furnished within one month after the completion of the part, without waiting for its incorporation into the machine as a whole. Detail drawings will be made to a scale of not less than one and one-half inches to the foot. General plans of the machinery in place in the vessel will be made to a scale of one-quarter of an inch to the foot. The pipe plans will be made to a scale of not less than three-eighths of an inch to the foot. The pipe plans will be divided into at least two parts—one showing steam and exhaust-pipes, and the other showing all other pipes. The pipe plans will be colored, in accordance with a schedule to be furnished, to indicate the purpose which the pipes are intended to serve, and accompanied by an explanatory index.

All drawings will be made on the best quality of tracing-cloth, all sheets being, as far as possible, multiples or sub-multiples of double-elephant size.

Detail drawings will be hatched, where in section, in accordance with a schedule to be furnished, to show the various metals employed.

204. CHANGES IN PLANS AND SPECIFICATIONS.

The contractor will make no changes in the plans or specifications without the approval of the Navy Department. In case it is thought advisable to make changes, the contractor will make application by letter to the Bureau of Steam Engineering, through the superintending naval engineer, stating the nature of the change, accompanied by complete plans and specifications of the proposed change, together with a statement of his estimate of the amount of increase or decrease in cost.

205. INSPECTION.

The work of construction of the boilers, machinery, and appurtenances shall be at all times open to inspection by officers appointed for such purpose by the Navy Department. Every facility will be afforded such inspectors for the prosecution of their work. All handling of material necessary for purposes of inspection will be done at the expense of the contractor. All test specimens necessary for the determination of the strength of material used will be prepared and tested at the expense of the contractor. The contractor will furnish the superintending naval engineer with a weekly list of the number of men of each class employed upon the work, together with a statement of the number of hours labor in each class.

206. OMISSIONS.

Any part of the machinery, or any article pertaining thereto which may have been inadvertently omitted from these specifications or from the official drawings, but which is necessary for the proper completion of the vessel, is to be supplied by the contractor without extra charge.

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